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Status of soil micronutrients in paddy soils of Zamfara State, Northwestern Nigeria.

***[1]A.A. Dogo, [2]A.U. Dikko, [3]M. Audu, [4]S.B. Shamaki and [5]M.T. Zubyr**

[1&5] Department of Agricultural Technology, College of Agric and Animal Science, Bakura, Zamfara
[2 &3] Department of Soil Science and Agricultural Engineering, Usmanu Danfodiyo University,Sokoto
[4] Department of Forestry and Environment, Usmanu Danfodiyo University, Sokoto, Nigeria

Abstract

The study was carried out to assess the status of soil micronutrients in Paddy Soils of Zamfara State, Northwestern Nigeria. Three sites in three local governments areas were purposively sampled along Sokoto River, and the local governments are; Maradun, Talata Mafara and Bakura. In each site four transects were established which were spaced at 500m apart. On each transect four sampling points were selected which were spaced at 100m apart and soil samples were collected at a depth of 0-30 cm given a total of 48 soil samples. The soil samples were analyzed for some physical and chemical properties as well as micronutrients. Results showed that the soil texture was sandy clay loam to clay loam and the soils were slightly acid 6.23, 6.21 and 6.26 for Maradun, Mafara and Bakura respectively. Organic carbon was low in all the sections 3.52, 3.26 and 4.16 g/kg respectively. CEC, Nitrogen and Phosphorus were rated medium in the entire site with values 10.12, 10.43, 11.95cmol/kg and 0.22, 0.26, 0.21g/kg and 2.49, 2.32, 2.11mg/kg, Potassium were low with values of 0.42, 0.29 and 0.52cmol/kg respectively. The micronutrients studied were Iron, Manganese, Zinc and Copper. Iron was high in all the 3 sites 17.13, 18.02 and 18.35mg/kg while manganese was medium in all sites with values 7.7, 10.28 and 7.84mg/kg. Zinc and Copper content were also high 2.83, 2.52, 2.33mg/kg and 1.82, 1.76, 2.35mg/kg respectively, statistically there was significant difference in Copper content but none in Zinc between the sections.

KEYWORDS: Soil status, Soil Micronutrients and Paddy soil

Corresponding Author's E-mail Address: anasdogo84@gmail.com
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1.0 Introduction

There is an increasing demand for information on soils as a means to produce food (Fasina *at el*., 2007). Soil plays a major role in determining the sustainable productivity of an agro-ecosystem. The sustainable productivity of a soil mainly depends upon its ability to supply essential nutrients to the growing plants (FOA, 1999). There are 16 natural elements (nutrients) that are essential for plant growth. Three elements (carbon, hydrogen and oxygen) make up 94% of the plant tissues and are obtained from air and water. The other 13 elements are obtained from the soil and are divided into two broad categories - 'macro' and 'micro'. These terms do not refer to the importance of the elements; macronutrients are required in greater amounts than micronutrients for normal plant growth (FOA, 2012).

Micronutrients are elements required in small quantities for higher plant growth and reproduction. The exact quantity needed varies with plant species and the specific element. Seven elements are generally considered as plant micronutrients, these include boron (B), copper (Cu), chlorine (Cl), iron (Fe), manganese (Mn), molybdenum (Mo), and zinc (Zn) (Soil Survey Staff, 2010).

Generally, studies on micronutrients status of Nigerian soils have been neglected in the past due to non- prevalence of their deficiency symptoms. This has made the information on soil micronutrient status of Nigeria savanna soils scanty. (Lombin 1983, Kparmwang *et al*., 1995 and Adeboye MKA, 2003) reported that limited studies have been conducted on the micronutrients status of soils within the savanna zone of Nigeria. However, the few investigations carried out so far have revealed micronutrient deficiency in some Nigerian savanna soils [Lombin 1983b, Lombin 1983a and Lombin 1983c]. Depletion of micronutrients in Nigerian savanna soils has resulted from intensively cultivated soil with high nutrient-demanding crops, highly weathered rocks and leaching. (Mustapha and Loks 2005) Reported that the use of new high yielding crop varieties which are nutrient demanding have unraveled micronutrient deficiencies in some Nigeria Savanna soils. The deficiency of micronutrients has become a major constraint to productivity, stability and sustainability of soils (Rangel, Z. 2003). In order to realize the full potentials of these soils, there is needed to take the inventory of their nutrient status including their distribution. If soil nutrients deficiencies that affect high productivity is not identified, monitored and alleviated, it will lead to critical deficiency levels. The need to understand the importance of micronutrients is highly imperative for improved productivity of both the soil and crops (Mustapha *et al*., 2011) The objective of this research therefore, is to assess the distribution of Fe, Mn, Cu and Zn in the study area as well as to compare soil micronutrients status between the selected local governments area, determine the physical and chemical properties of the soils in each of the selected local government areas.

1.2 Scope of the Study

The study covered three sites in three Local Government Areas (LGA) of Zamfara state namely, Maradun, Talata Mafara and Bakura

2.0 Materials and Methods

2.1 Study Area

The study area was selected from three local governments (Maradun, Talata Mafara and Bakura) under Bakalori Irrigation Project in Zamfara State, the area lies between latitude 12° 34'- 12° 42'N and longitudes 6° 14'-5° 52' E [14]. The climate of the area is characterized by a hot dry season lasting from October to May and a rainy season that usually starts in mid-May and ends in September. Long-term mean annual rainfall ranges from 500 mm-900 mm, with considerable inter annual variations. The annual temperature averages 27°C with a minimum of 17°C (December/January) and maximum of 40 0 C in April/May (Anonymous, 2013).

2.2 Soil Sampling and Handling

Three sites in three local governments areas were purposively sampled along Sokoto River, and the local governments are; Maradun, Talata Mafara and Bakura. In each site four transects were established which were spaced at 500m apart. On each transect four sampling points were selected which were spaced at 100m apart and soil samples were collected at a depth of 0-30 cm given a total of 48 soil samples. The soil samples were analyzed for some physical and chemical properties as well as micronutrients. The soil samples collected were properly labeled and stored in polythene bags prior to laboratory analysis. In the laboratory, each sample was separately air dried and crushed gently using pestle and mortar. The crushed soil samples were sieved with 2 mm sieve and the fine earth fractions (<2 mm separates) were used for all the laboratory analyses.

2.3 Laboratory Analyses

The particle size distribution was determined using the hydrometer method after dispersing with sodium hexametaphosphate (Bouyoucus, 1951). The soil pH was determined in 1:1 soil/water suspension using a glass electrode pH meter while Organic Carbon was determined using wet oxidation method of (Walkley and Black, 1934). Cation exchange capacity was determined using the NH4OAc saturation at pH 7, while the leachate was used to determine the exchangeable bases. Total and available micronutrients (Zn, Cu, Fe and Mn) were determined using HClO4/HNO3 and 0.1M HCI solution respectively (Osiname *et al*., 1973), and were read using atomic absorption spectrophotometer at appropriate wave lengths.

2. 4 Data Analysis

Data collected were subjected to Analysis of Variance (ANOVA) to test the significance difference between the locations. Where significant difference exists, means were separated using Duncan's New Multiple Range Test (DNMRT). SPSS Statistical package was used for the analysis.

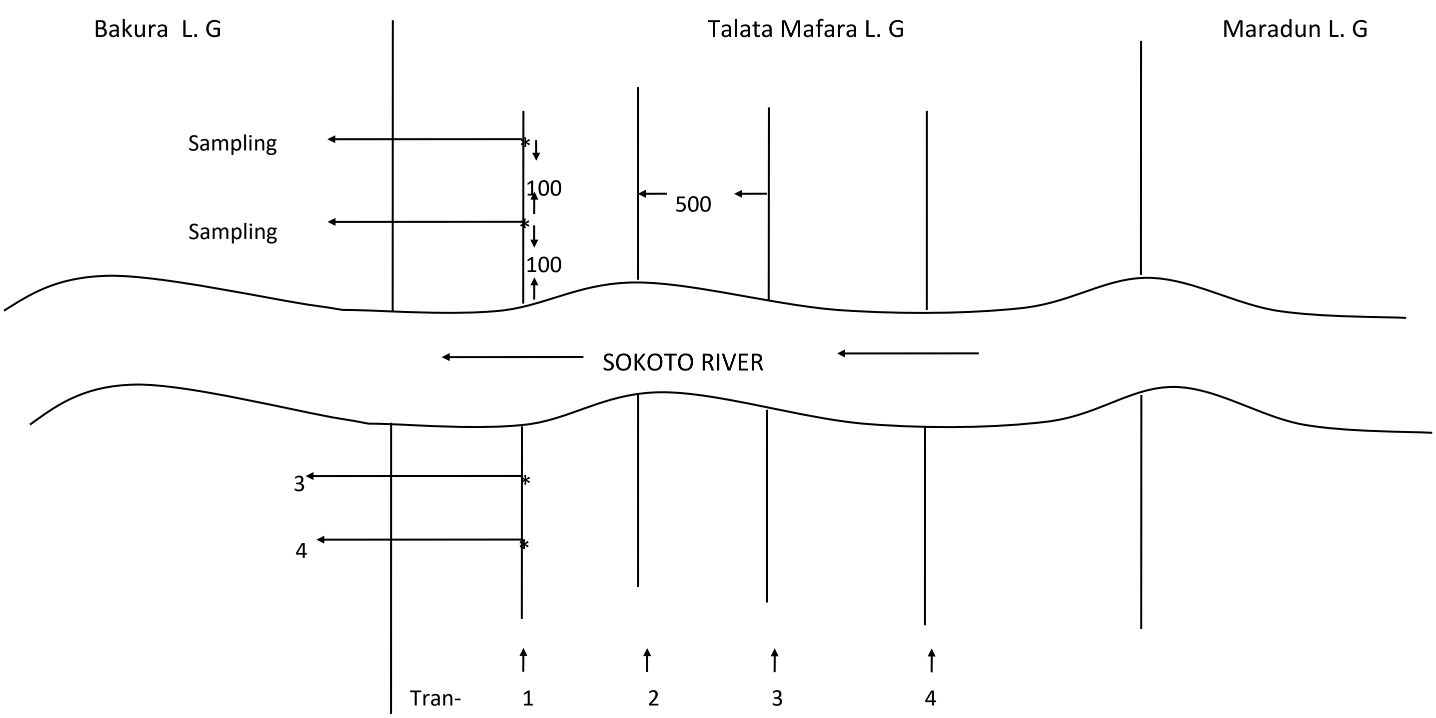

Fig1: A Sketch of the sampling site protocol

3.0. Results and Discussion

3.1. Chemical and Physical Properties of surface soil

3.1.1. Soil pH

The results of some physical and chemical properties of the soils are presented in Table 1. The mean pH values for the soils in Maradun, Talata Mafara and Bakura were 6.23, 6.21 and 6.26 respectively. Similar results were obtained by Sani *et al*., (2020) in the study carriedout in Katsina, Northwest Nigeria, with the mean pH range values of 6.27-6.46. (Esu, 1991), rated soil with pH 5.0-5.5 as strongly acid, 5.6-6.0 as moderately acid and 6.1-6.5 as slightly acid. Based on this rating, the soils of the area were within the slightly acid range. This could be attributed to the removal of basic cations from the surface soil to the lower depth and/or the use of some acid forming fertilizers such as urea for agricultural purposes. However statistical analysis showed that there was no significant difference between the pH of the three locations.

3.1.2. Organic Carbon

The results of organic carbon content are presented in Table 4. The mean values are 3.52gkg^{-1}, 3.46gkg^{-1} and 5.16gkg^{-1} for Maradun, Talata Mafara and Bakura soils respectively. Wadatau *et al*., (2011) reported a mean value of 3.0gkg^{-1} for soils of flood plain of Rima River. All soils of the study area were rated low in organic carbon as their values were < 10 gkg^{-1} as suggested by (Esu, 1991). The low organic carbon content of the soils of the studied area may be attributed to the continuous cultivation of the land by the farmers for both rainy and dry season farming. Low organic carbon values have been reported by Bamikole *et al*., (2020) for the Nigeria Savannah Soils. Statistically, there was no significant difference between the organic carbon content of the three locations.

Table 1: Some Chemical and Physical Properties of Soils from Maradun, Mafara and Bakura in the flood plain along River Sokoto

Location	pH	Org. C	CEC	Sand	Sand	Silt	Clay
	(in H_2O)	(gkg^{-1})	(cmolkg-¹) ←			(gkg^{-1}) →	
Maradun	6.23 ± 0.06	3.52 ± 0.43	10.12 ± 0.83^a	512.5 ± 2.32^a	512.5 ± 2.32^a	220.8 ± 1.81^b	266.7 ± 0.79^b
Talata Mafara	6.21 ± 0.14	3.26 ± 0.36	10.43 ± 1.09^a	566.1 ± 2.73^a	566.1 ± 2.73^a	171.4 ± 2.08^b	262.4 ± 2.08^b
Bakura	6.26 ± 0.09	4.16 ± 0.46	11.95 ± 1.38^b	361.4 ± 2.29^b	361.4 ± 2.29^b	316.2 ± 1.79^a	322.3 ± 1.06^a
Significant	Ns	Ns	**	**	**	**	**

Means followed by the same letters(s) within a column are not significantly different (ns), (P > 0.05)

3.1.3. Cation Exchange Capacity

The mean values of cation exchange capacity (CEC) for Maradun, Talata Mafara and Bakura soils are presented in Table 4. The CEC values were 10.12cmolkg^{-1}, 10.43cmolkg^{-1} and 11.95cmolkg^{-1} for Maradun, Talata Mafara and Bakura respectively. Sani *et al*., (2020) reported CEC value of 10.0 cmolkg in northern guinea savannah, Nigeria. (Esu, 1991) Classified soils with CEC < 6.0cmolkg as low, 6-12 as medium and > 12.0cmolkg^{-1} as high. According to this classification, soils of the study area were generally medium in CEC.

Addition of organic matter by the farmers might have contributed to the medium CEC of the study area and clay content in the soil of the study area might have also contributed to the medium CEC. Statistical analysis showed that there was significant difference between the CEC of the three locations. The CEC was statistically similar in Maradun and Talata Mafara but statistically higher in Bakura. There was progressive increase in CEC from Maradun down to Bakura, in which Bakura had the highest CEC value followed by Talata Mafara then Marudun with the least value.

3.1.4. Particle Size Distribution

The results of soil particle size distribution are presented in Table 1. The result showed that the soils of Maradun (512.5 gkg^{-1} sand, 228.0 gkg^{-1} silt and 266.7 gkg^{-1} clay), and that of Talata Mafara (566.1 gkg^{-1} sand, 171.4 gkg^{-1} silt and 262.4 gkg^{-1} clay) were sandy clay loam while that of Bakura was clay loam (361.4 gkg^{-1} sand, 316.2 gkg^{-1} silt and 322.3 gkg^{-1} clay) respectively. Maniyunda, (2013) reported soil texture of loamy sand for soils of Funtua northwestern, Nigeria.

The change in texture from Maradun down to Bakura may be partly attributed to the parent materials from which the soils were derived and partly from the alluvial depositions following the periodic flooding of the river. This trend has affected the overall CEC of the soils of the study area and this is in line with the finding and conclusions of (Singh, 1997) that soil texture can give a general indication of soil quality. However statistical analysis showed that there was significant difference between the particle size distributions of the three locations. Particle size distribution was statistically similar in Maradun and Talata Mafara but statistically different with that of Bakura.

3.1.5. Total Nitrogen (N)

The results of total nitrogen content are presented in Table 2. The mean values of the studied area were 0.22 gkg^{-1}, 0.26 gkg^{-1} and 0.21 gkg^{-1} for Maradun, Talata Mafara and Bakura soils. Low nitrogen values were obtained from soils of Kano State (Shehu *et al*., 2015). This result indicated that the soils of the study area were medium in total nitrogen. According to (Esu, 1991), soils with values of 0.1 – 0.2 are rated medium in total nitrogen. The medium level of total nitrogen of the study area may be attributed to application of nitrogenous fertilizers. Nitrogen has been reported to be the most limitating plant nutrient in tropical soils (Brady and well, 1999). However statistical analysis showed that there was no significant difference between the nitrogen content of the three locations.

3.1.6. Available Phosphorus (P)

Result of available P is shown in Table 2. Available phosphorus mean content of the Maradun, Talata Mafara and Bakura soils were 2.49 mgkg^{-1}, 2.32 mgkg^{-1} and 2.11 mg kg^{-1} respectively. Shehu *et al*., (2015) also obtained low phosphorus content for soils of Kano State. This result conforms with the earlier findings of the International Centre for Tropical Agriculture (ICTA, 2006) that phosphorus is one of the limiting nutrient to crop in west African soils and about 8% of the African soils have inadequate supply of phosphorus. (Esu, 1991) classified soils with < 10mgkg^{-1} in available phosphorus as low in available phosphorus.

The progressive decline in the available phosphorus from Maradun to Bakura might be related to the parent materials from which the soils were formed. Statistically there was no significant difference between the phosphorus of the three locations.

The low levels of calcium in the soils might be attributed to the slightly acid condition of the soil. Statistical analysis showed that there was significant difference between the calcium of the three locations. Maradun and Talata Mafara are statistically similar but were statistically different to that of Bakura soils. Talata Mafara soils have the highest calcium content followed by Maradun and then Bakura soils.

3.1.7. Exchangeable Potassium (K)

The results of exchangeable potassium content are presented in Table 5. Potassium content varied from 0.42cmolkg^{-1} for Maradun soils, 0.29cmolkg^{-1} for Talata Mafara soils and 0.52cmolkg^{-1} for Bakura soils respectively. According to (Esu, 1991) exchangeable potassium was rated low at < 0.15 cmolkg^{-1}, medium at 0.15 to 0.3cmolkg^{-1} and high at> 0.3cmolkg^{-1}. Based on this rating, the soils of the study area were all rated low in exchangeable potassium. Similar results were obtained by (Muntaqa *et al*., 2013) with a value of 0.34cmolkg^{-1} for rice field at Talata Mafara, Zamfara State. The low exchangeable potassium content of the studied area may be attributed to soil texture of the area which is sandy loam. Statistical analysis showed that there was significant difference between the potassium content of the three locations. Maradun soil was statistically similar to both Talata Mafara and Bakura, but Talata Mafara was statistically different to that of Bakura soils.

3.1.8. Sodium (Na)

The results of sodium concentration are presented in Table 2. Sodium content obtained were 0.74cmolkg^{1} for Maradun soils, 0.86cmolkg^{-1} for Talata Mafara soils and 0.76cmolkg^{-1} for Bakura soils. According to (Esu, 1991), sodium values < 0.1cmolkg^{-1} are classified as low in sodium; 0.1 to 0.3 cmolkg^{-1} as medium and > 0.3cmolkg^{-1} is considered as high in sodium content.

Table 2: Some Chemical Properties of Bakura, Mafara and Maradun Soils along River Sokoto Location

	N (%)	P mgkg-¹	Ca ←	Mg (+) cmolkg-¹	K →	Na
Maradun	0.22 ± 0.01	2.49 ± 0.01	0.31 ± 0.01^{a}	0.27 ± 0.03	0.42 ± 0.03^{ab}	0.74 ± 0.01^{b}
Talata Mafara	0.26 ± 0.01	2.32 ± 0.01	0.32 ± 0.02^{a}	0.22 ± 0.02	0.39 ± 0.03^{b}	0.86 ± 0.03^{a}
Bakura	0.21 ± 0.01	2.11 ± 0.01	0.22 ± 0.01^{b}	0.28 ± 0.02	0.52 ± 0.05^{a}	0.76 ± 0.05^{ab}
Significant	Ns	Ns	**	Ns	**	**

Means followed by the same letters(s) within a column are not significantly different (ns), (P > 0.05)

This indicates that, the soils of the study area were generally high in sodium content. Wadata *et al*., (2011) obtained a range value of 1.4–1.9 cmolkg^{-1} in soils of Rima river flood plain. The high level of sodium in the studied area may be attributed to poor drainage and irrigation water that is use in the area. Statistical analysis showed that there was significant difference between the sodium content of the three locations of the studied area. Bakura soil was statistically similar to both Talata Mafara and Maradun, but Talata Mafara was statistically different to that of Maradun soils.

3.2. Soil Micronutrients

The total content of any micro-nutrient element in soils gives very little indication of its availability to plants, the amount of micro-nutrient that is soluble in a weak extract (water, ammonium acetate, dilute acid and complexing agents) usually gives more useful information about plant availability (Udoh *et al*., 2008). In this study, effort was made to study the total and available micronutrients of the soils of the study area.

3.2.1. Total Micronutrient (Fe, Mn, Zn and Cu)

The mean values of the total micronutrient elements in the soil of the studied area are presented in Table 3.

The mean values of total Iron content of the soil of the studied area were; 30.67 mgkg^{-1} for Maradun, 32.03 mgkg^{-1} Talata Mafara and 31.67 mgkg^{-1} for Bakura soils. Similar value of 41.13mgkg^{-1} was obtained by Bassirani *et al*., (2011) in the soil of India. Statistically result showed that all the soils of the studied area were not significantly different at 5% level of significance.

The total manganese values of the soil of the studied area were 11.64 mgkg^{-1} for Maradun soils, 12.68mgkg^{-1} for Talata mafara soil and 11.72 mgkg^{-1} for Bakura soils. Udoh *et al*., (2008) reported a similar value in the flood plain soils of Akwa-ibom. The results showed no significant difference in manganese content between the soils of the three sampled sites.

Total zinc content of the study area was 7.05 mgkg^{-1} for Maradun soils, 7.90 mgkg^{-1} for Talata Mafara soils and 7.08 mgkg^{-1} for Bakura soils respectively. Statistically the total zinc content of the study area indicated that there was no significant difference in zinc contents of the three sampled sites.

Total copper content of the Maradun, Talata Mafara and Bakura soils are, 4.62 mgkg^{-1}, 4.64 and 6.09 mgkg^{-1} respectively. However statistical analysis showed that the soils of Maradun and Mafara were statistically similar but statistically different to Bakura soils. Bakura soils have the highest copper content followed by Talata Mafara and then Maradun soils.

3.2.2. Available Soil Micronutrients (Fe, Mn, Zn and Cu)

The available micronutrients determined were Fe, Mn, Zn and Cu. The results were presented in Table 3.

Available iron content of the soil of the studied area was 17.13mgkg^{-1}, 18.02 mgkg^{-1} and 18.35mgkg^{-1} for Maradun, Talata Mafara and Bakura soils respectively. Esu (1991) gave a range of <4.5mgkg^{-1}, 4.5-10mgkg^{-1} and > 10mgkg^{-1} as low, medium and high iron content of soils respectively. Similar results were obtained elsewhere in India by Bassirani *et al.,* (2011). This indicates that all the soils of the study area were high in iron content. Statistical analysis showed that there is no significant difference in iron content between the soils of the study area.

Available manganese of the soils of Maradun, Talata Mafara and Bakura are 7.7mgkg^{-1}, 10.28mgkg^{-1} and 0.89mgkg^{-1} respectively. Esu (1991) gave the critical limits of Manganese in soils as < 5 mgkg^{-1} (low), 5-10 mgkg^{-1} (medium) and > 10 mgkg^{-1} (high). Oyinlola and Chude, (2010) obtained mean value of 9.2 in Zaria, Kaduna State. This indicates that all the soils of the study area were medium in manganese content.Statistically there was no significant difference between Maradun and Bakura but there was significant difference between Mafara and that of Maradun, and Bakura soils.

Available zinc of the Maradun, Talata Mafara and Bakura soils were 2.83mgkg^{-1}, 2.52mgkg^{-1} and 2.33mgkg^{-1} respectively. Iyaka and Kakulu (2009) reported a Zinc range value of 2.8mgkg^{-1} to 7.5mgkg^{-1} in soils of Niger State. The soils of the studied area were rated high in Zinc content as the values were above 2.0 mgkg^{-1}. Esu (1991) rated < 0.8 mgkg^{-1} as low and > 2.0 mgkg^{-1} as high. The zinc content increase as you move along the river from upper to the lower part of the study area and these may be attributed to the farming activity which is high in the upper part followed by middle part than the lower part.

The values obtained in these studies were indeed higher than the mean Zinc value of 0.58 mgkg^{-1} obtained from the soils of Gombe State, Nigeria by Mustapha *et al*., (2010). Statistically there was no significant difference between the available zinc of the three locations.

Available copper content in the studied area were 1.82mgkg^{-1}, 1.7mgkg^{-1} and 2.35mgkg^{-1} for Maradun, Talata Mafara and Bakura respectively. According to Esu (1991), Copper content of < 0.2 mgkg^{-1} is low, 0.2-1.0 mgkg^{-1} medium and> 1.0 mgkg^{-1} Copper content was high Going by this rating. Godwin and Omolola (2012) reported a mean value of 1.27mgkg^{-1} for the soils of Abeokuta. Statistically there was significant difference between Talata Mafara and Bakura soils, but the Talata Mafara and Maradun soils were statistically similar in copper content, Bakura soils had the highest available copper content followed by Maradun and Talata Mafara respectively.

Table 3: Distribution of Total and Available Micronutrients at the three locations (Maradun, Talata Mafara and Bakura Soils) along River Sokoto

Location	**Fe** ←	**Mn** **mgkg-¹**	**Zn** →	**Cu**	**Fe** ←	**Mn** **mgkg-¹**	**Zn** →	**Cu**
Maradun	30.67 ± 0.16	11.64 ± 0.64	7.05 ± 0.11	4.62 ± 0.13^{b}	17.13± 0.11	7.7± 0.06^{b}	2.83± 0.05	1.82 ± 0.11^{b}
Talata Mafara	32.03 ± 0.2	12.68 ± 0.16	7.90 ± 0.1	4.64 ± 0.13^{b}	18.02 ± 0.1	10.28 ± 0.81^{a}	2.52± 0.06	1.76 ± 0.12^{b}
Bakura	31.67 ± 0.22	11.72 ± 0.1	7.08 ± 0.13	6.09 ± 0.37^{a}	18.35± 0.11	7.84± 0.07^{b}	2.33± 0.37	2.35 ± 0.13^{a}
Significant	Ns	Ns	Ns	**	Ns	**	Ns	**

Means followed by the same letters(s) within a column are not significantly different (ns) (P > 0.05)

4.0. Conclusion

The results obtained from this study have shown that out of the four soil micronutrients investigated namely: Fe, Mn, Zn, and Cu. Fe, Zn and Cu were high in concentrations, while Mn was medium in concentration. The distribution of these micronutrients in the study area suggests that supplementary application of Mn will be required for sustainable rice production in the soil studied, while Fe, Zn and Cu are not deficient in such soils. Na was high as such there is tendency of sodicity problem, high Na concentration needs to be checked.

The following recommendations were made based on the findings of the study.

1. Annual check-up of the soil condition is required to ascertain the status of the soil
2. The low organic matter, phosphorus and some exchangeable bases in the area can be enhance by increased use of organic matter in addition to the application of phosphatic fertilizers

References

Fasina, A.S., Omolayo, F.A., Ajayi, SO., and Falodun, A.A. (2007). Influence of Land Use on Soil Properties in Three Mapping Units in Southwestern Nigeria-Implications for Sustainable Soil Management. In Uyovbisere, E.O, Raji, B.A,

FAO (1999). World Reference Base for Soil Resources.World Soil Resources Rep. vol. 84. Food and Agricultural Organisation of the UN, Rome, Italy, 161p. FAO (2006). Guidelines for Soil Description. Fourth Edition. 109pp

Available:http://www.fao.org/docrep/008/ae 939e/ ae939e06.htm

Soil Survey Staff, (2010). Keys to Soil Taxonomy. 11th Edition. USDA/NRCS, Washington, DC. 338pp. Sombroek, W.G. and Zonneveld, I.S. (1971). Ancient Dunes Fields and Fluviatile Deposits in the Rima. Sokoto River Basin Soil Survey Paper No.5, Netherland Soil Survey Institute, Wageningen, pp109.

Lombin G. Evaluating the micronutrient fertility of Nigerian Semi - Arid Savanna Soils: Zinc Soils. Soil Science. 1983a;136:

Kparmwang T, Chude VO, Esu IE. Hydrochloric acid (0.1M) and DPTA extractable and total iron manganese in basaltic soil profiles of the Nigerian savanna. Communications Soil Science Plant Analysis. 1995;26:2783-2796.

Adeboye MKA. Micronutrients status of the soil of the lower Gongola River Basin: Manganese and Copper. Spectrum Journal. 2003;10:57–64.

Lombin G. Evaluating the micronutrients fertility of Nigeria's semi-arid savanna soils. II Zinc. Soil Science. 1983b;136:42-47.

Lombin G. Evaluating the micronutrient fertility of Nigeria semi-arid savanna soils. Boron and Molybdenum. Soil Science Plant Nutrition. 1985;13:12-25.

Mustapha S, and Loks N.A. Distribution of available zinc, copper, iron and manganese in the fadama soils from two distinct agroecological zones in Bauchi State, Nigeria. J. Environ. Sci. 2005;9(2) 22-28.

Rangel, Z (2003). Heavy Metals as essential nutrients; Heavy metals stress in Plant: Molecules to Ecosystems. Springer-Verlag, Berlin, Heidelberg, Pp. 271-294.

Mustapha S.M., N. Voncir, S. Umar and N.A Abdulhamic, (2011). Status and Distribution of some Available Micronutrients in the Haplic Usterts of Akko Local Government Area, Gombe State. Nigeria. *International Journal of Soil Science,* 6:267-274.

Anonymous. Zamfara State physical setting, people, population and settlement; 2013. (Accessed 12 May, 2015) Available:www.onlinenigeria.com/links/zamfarastateadv.asp?blurb=393

Bouyoucus CA. A re-calibration of the hydrometer for making mechanical analysis of soils. Argon. J. 1951;31:510- 513.

Walkley A, Black CA. Acid extractable Zn in soil in relation to occurrence of Zn deficiency symptoms of corn: A method of analysis. Soil Sci. Soc. Am. Proc. 1934; 12:143-148.

Osiname OA, Schutte EK, Corey RB. Soil test for available Cu and Zn in soils of western Nigeria. Journal of Soil Science and Food Agriculture. 1973;24: 1341-1349.

Wadatau D, Dikko AU, Audu M, Abubakar GA, Isah AD. Assessment of micronutrient status of the flood-plain soils of Sokoto Rima River, North Western Nigeria. Proceeding of the 45th Aunnual Conference of the Agricultural Society of Nigeria (ASN). 24th-28th Oct. 2011;537541.

Esu TE. Detail soil survey of NIHORT farm at Bunkure, Kano State Nigeria. Institute of Agricultural Research, Zaria. 1991;72.

Singh BR. Characteristics of fadama soil in Sokoto-Rima River Basin in Dundaye District. In: B.R. Singh (Ed), Management of Marginal Land in Nigeria. Proceedings of Soil Science Society of Nigeria, Usman Danfodiyo University, Sokoto. 1997;147- 152.

Brady, N.C and R.R Well (1999). The Nature and properties of soils. 10th ed. Prentice-Hall Inc. Upper Saddle River, New Jersey. 960p.

ICTA, (2006). Nitrogen and phosphorus excretion on commercial rabbit farms: calculations based on the input-output balance.

http://riunet.upv.es/handle/10251/9747?show=full&locale-attribute=en

Muntaqa, H. O.O Agbede, and U.A Umar (2013). Comparative Analysis of fertility in irrigation and non- irrigated Rice fields. *Pacific Journal of Science and Technology* 14(2) 468 – 472.

Udoh, B.T, Ibia T.O and Udoh B.U (2008). Assessment of Micronutrients status of inland depression and flood plan (Wetland) soil in Akwa Ibom state South-Eastern Nigeria. *Journal of Tropical Agriculture, Food, Environment and Extension.* 7(20): 156- 161.

Vol. 3 (3)

Bassirani, N., Abolhassani M. and Galavi M, (2011). Distribution of available Micronutrients as related as related to the soil characteristics of Hisser; Haryana (India). *African Journal of Agricultural Research* 6 (18): 4239 - 4242.

Godwin A. A. and M. A. Omolola (2012). Properties and Available Micronutrient Status of Some Soils Derived From Abeokuta Formation in Nigeria. *Archives of Agronomy and Soil Science*. Pp 1-16

Iyaka, Y. A., and S. E. Kakulu (2009). Copper and Zinc Contents in Urban Agricultural Soils of Niger State, Nigeria. *International Multi-Disciplinary Journal, Ethiopia*

Mustapha, S., H. K. Mamman and N. A. Abdulhamid, (2010). Status and distribution of exchangeable micronutrients in Haplustults in Yamaltu-Deba Local Government Area, Gombe State, Nigeria*. Journal of Soil Science and Environmental. Management*., 1: 200-204.

Sani A, R. I, Shahrudin, Z. N. Ahmad and S.S. Noma. Soil Variability Assessment for Sustainable Agriculture in Katsina State,Northwest,Nigeria.https://www.researchgate.net/publication/348370211. July – August 2020 ISSN: 0193-4120 Page No. 182- 192

Bamikole P. A, A. O. Olakayode, D. J. Oyedele, and F. O. Tijani. Selected physical and chemical properties of soil under different agricultural land-use types in Ile-Ife, Nigeria Heliyon. 2020 Sep; 6(9): e05090. Published online 2020 Sep 28. doi: 10.1016/j.heliyon.2020.e05090 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7527570/

Maniyunda I,, B. A. Raji , M. G. Gwari. International Journal of Science and Research (IJSR), India Online ISSN: 2319-7064 Volume 2 Issue 9, September 2013 www.ijsr.net Variability of Some Soil Physicochemical Properties on Lithosequence in Funtua, North - Western Nigeria L. M.

Shehu,B. M. and J. M. jibril and A. M. Samndi. Fertility Status of Selected Soils in the Sudan Savanna Biome of Northern Nigeria, February 2015 International Journal of Soil Science 10(2):74-83DOI:10.3923/ijss.2015.74.83

E.Y. Oyinlola and V.O. Chude (2010) Status of Available Micronutrients of the Basement Complex Rock – Derived Alfisols in Northern Nigeria Savanna. Tropical and Subtropical Agroecosystems, 12 (2010): 229 - 237