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Variability of Extractable Micronutrients in Selected Soils of a Guinea Savannah Agro-Ecology of Oyo State, Southwestern Nigeria

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Abstract

Micronutrients are involved in the key physiological processes of photosynthesis and respiration in plants and deficiencies in micronutrients could lead to significant yield loss in crops. The status of micronutrients in soil has not been given adequate attention in soil fertility studies. This study was carried out to determine both the vertical and spatial variability of selected micro-nutrients (Mn, Fe, Cu and Zn) within and across a four soil types which were Oshe series (Oxyaquic Haplustalf), Fashola series (Typic Plinthustalf); Temidire series (Rhodic Plinthustalf) and Kishi series (Kanhaplic Haplustalf) identified on a landscape near Ogbomosho in Oyo state. Soil samples were collected in grids of 150 × 200 m at depths of 0-15 cm, 15-30 cm, 30-60 cm and 60-90 cm across the approximately 250 ha study area. The soils were subjected to routine analysis using standard laboratory procedures. The analytical results of the pH, organic C, exchangeable cation exchange capacity and extractable micronutrients (Fe, Mn, Cu and Zn) were subjected to descriptive analysis to determine the vertical and spatial variability of these micronutrients in the study area using the critical values of the co efficient of variation. The soils were slightly acidic and tend towards neutral with mean pH of 6.1-6.7 which is ideal for most crops. The ECEC and the Organic Carbon (OC) were observed to be relatively moderate in content and variation across the landscape which is an indication of a relatively fertile soil. The micronutrients (Mn, Fe, Cu, and Zn) were above their critical level and they have low variation both vertically and spatially across the mapping units except for Zn which had high variation in Fashola soil series. While soils of this area are relatively good in native nutrients, the weak aggregations and sandy nature of surface soils are prone to erosion which could lead to rapid degradation. The soils should be properly managed through a proper site specific fertility management programme to maintain a good nutrient status for continuous cropping.

Keywords: Photosynthesis; Micronutrients; Agriculture; Plant nutrition; Fertility; Zinc deficiency

Introduction

The soil is a production factor in agriculture that needed to be understood before it could be improved [1]. The nutrients taken-up by the plants in higher concentrations are categorized as macronutrients, while micronutrients are the one needed in smaller quantities. Out of 16 plant nutrients, zinc, copper, iron, manganese, molybdenum, chlorine and boron are referred to as micronutrients. The importance of these micronutrients for different physiological processes in plant life is well understood, as they are required in smaller quantities. Therefore, when a nutrient becomes deficient in the soil, the plant growth may suffer and the situation results into crop failure or loss of yield.

Micronutrients often act as cofactors in enzyme systems and participate in redox reactions, in addition to having several other vital functions in plants. Most importantly, micronutrients are involved in the key physiological processes of photosynthesis and respiration and their deficiency can impede these vital physiological processes thus limiting yield gain. For example, for rice (*Oryza sativa* L.), Zinc deficiency is a major yield-limiting factor in several Asian countries. The primary source of nutrients in the soil is the weathering of the parent material in the earth's crust [2]. Zinc, boron and molybdenum are relatively scarce.

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 [3]. 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.

Increased interest on micronutrients as limiting factors in crop growth and yield in the guinea savanah agroecology of Nigeria is due to long term cropping which has removed measurable amounts of these nutrients, widespread use of animal measures which has decreased and also top soil has been removed through erosion [4]. It is reasonable therefore to pay attention to the adequacy of micronutrients in crop production, although

used in smaller quantities than the other essential nutrients; they are just as important for proper plant nutrition. Micronutrient is deficient in most agricultural soils in developing countries. Zinc is deficient in half of the number of agricultural lands and Boron follows. The deficiency of copper, molybdenum, and manganese were smaller [5]. It was generalized that the concentration of micronutrients in plants can be linked to the soil. Plant species differ dramatically in their inherent abilities to extract each nutrient from a given soil. This and varietal differences operate within each target species such that plant breeding species can greatly increase the adaptation to a deficient soil. Formal studies of micronutrients efficiency traits have shown that copper efficiency appears in cereals to be due to single major gene. In manganese deficient growing soil, the trait was polygenic, yet it can be usefully manipulated in breeding progamme using molecular markers that have been developed. Soil deficiencies of micronutrients that are essential for plant growth can lead to lower crop yields. During the past decade, soil micronutrient deficiencies have been ascertained primarily for zinc, and to a lesser extent for boron and molybdenum.

The quest for a sustainable food security in Nigeria through the use of information on nutrient status of soils has become imperative. Several researchers have advocated the need for assessing the micronutrients status of soils and Nigeria in particular. 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 [6]. This study was carried out, therefore, to determine the status of micronutrients in the and evaluate the vertical and spatial variability of these micronutrients in the identified soil types in the study area.

Materials and Methods

Description and location of the study area

The study was conducted at Oko Maro village near Ogbomosho, Orire Local Government Area (LGA) of Oyo state. The field is located between Latitude 8.52123–8.53515°N and Longitude 4.23503–4.24660°E. The area lies mostly on plains which are punctuated by rocky outcrops of schists and quartzites with series of hills having slopes up to 8% and elevations reaching 119-155 m meters. The area exhibits the typical tropical climate of averagely high temperatures, high relative humidity and generally two rainfall maxima regimes during the rainfall period of March to October. Average daily temperature ranges between 25℃ (77°F) and 35°C (95°F) almost through-out the year [6]. Rainfall figures averaged 1200 mm. the area is characterized by derived savannah agro-ecology (Figure 1).

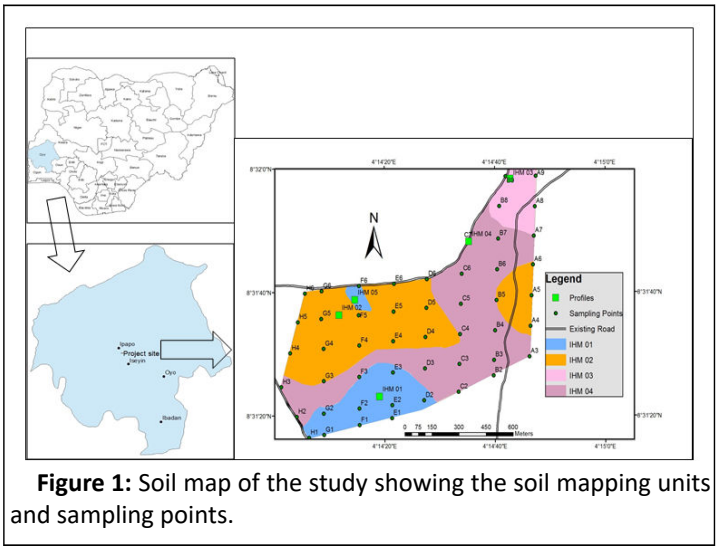

Figure 1: Soil map of the study showing the soil mapping units and sampling points.

Field work

This study was carried out along with a soil survey described by Orimoloye, et al. Transects were laid 200 m apart and examination points were sited at 150 m interval along the transects. At each examination point, samples were collected at depths 0–15 cm, 15–30 cm, 30–60 cm, 60–90 cm and 90–120 cm, except where impervious under-layer or high water table did not permit angering to the depth of 120 cm. Soil types were delianated and were further studied in detail in standard soil profiles measuring 2 m by 1.5 m to a depth of 1.8 m. Soil samples collected from examination points and the soil horizons were subjected to routine soil analysis.

Laboratory analysis

The soil samples collected were air dried, crushed, and sieved using 2 mm and 0.5 mm mesh sieve. The particle size analysis was carried out using the Bouyous hydrometer method [7]. The soil pH was determined in 1:1 ratio soil-solution mixture of water and KCl using glass electrode pH meter (Electrometric method). Organic carbon was analyzed using the dichromate oxidation method. Total nitrogen was determined by the Kjedahl oxidation method. Available phosphorus was extracted with Bray P1 solution and P concentrations were assayed using the ascorbic acid blue colour method. Exchangeable bases (K, Na, Ca and Mg) and micronutrients (Cu, Zn, Fe and Mn) were extracted with Melich III solution. Na and K were determined by flame photometry while all other bases and micronutrients were while the Effective Cation Exchange Capacity (ECEC) was calculated by the summation of the values of exchangeable cations. Exchangeable acidity (Al^{3+} and H^{+}) was leached in 1 N KCl and was titrated against 0.01 N NaOH.

Soil taxonomic classification

The soil types on the study area were classified using the guidelines of USDA soil taxonomy and the World Reference Base (WRB) system. The classifications were correlated with the local classification system of soils on basement complex parent rock origin as described by Murdoch, et al.

Statistical analysis

Descriptive statistics mean standard deviation and coefficient of variation for each mapping unit and profile pits were calculated using GenStat package. The variability of each property was measured by the Coefficient of Variation (CV) expressed as percentage. The higher the CV, the more variable the property [8]. The levels of variability were evaluated using the critical values for coefficient of variation as described by Olatunji, et al.

Results and Discussion

Four mapping units were discovered in the study area and the taxonomic classification together with the proportion of land area covered by each soil type are presented in Table 1. The soil in mapping unit IHM 01 is classified as Oxyaqic Haplustalf by USDA soil taxonomy and Stagnic Luvisol Fluvic by WRB. This mapping unit is at the lower slope of the study area with impeded drainage and water-logging and covers 14.50 Ha of the total land area which is about 14.43% [9]. Hydro-morphic mottles present in the profile pit indicate that there is fluctuation in the water table. Iron-Manganese concretions were observed from 60 cm depth. Parent material is granite gnesis and the profile length is 153 cm. Soil colour ranges from gray to Olive yellow; with soil texture ranging from Sandy loam on the top soil to Sandy Clay Loam down the profile pit. The soils are slightly acidic with pH value ranging from 6.2-6.5. Soils in this mapping unit have high base saturation with mean values 99.01% and 99.25% for vertical and spatial respectively. The CV micro-nutrients vertically include: Manganese; 8.27%, iron 10.48%, copper 4.72%, and zinc 32.30%; while those (CV) obtained spatially at 0-30 cm include: Manganese: 10.92%, iron 12.93%, copper 0.49%, zinc; 28.80%. Organic carbon ranges from moderate to very high for both the vertical and spatial distribution with mean values of 9.77 and 20.33 respectively (Table 2).

Table 1: Taxonomic classification of mapping units on the study site.

Soil mapping unit	Area (%)	Local	USDA soil taxonomy (Soil survey staff 2014)	WRB (FAO/ IUSS 2014)
Mapping unit (IHM 01)	14.34	Oshe series	Oxyaquic haplustalf	Stagnic luvisol (Fluvic)
Mapping unit (IHM 02)	35.73	Fashola series	Typic plinthustalf	Petric plinthosol (Eutric)
Mapping unit (IHM 03)	8.66	Temidire series	Rhodic plinthustalf	Petroplinthic lixisol (Rhodic, Eutric)
Mapping unit (IHM 04)	41.27	Kishi seies	Kanhaplic haplustalf	Haplic lixisol (Vetic)

Table 2: Vertical variability of micro-nutrients in soils of the study site.

Variables	Oshe series (Oxyaquic haplustalf)			Fashola series (Typic plinthustalf)			Temidire series (Rhodic plinthustalf)			Kishi series (Kanhaplic haplustalf)		
	Mean	SD	CV %	Mean	SD	CV %	Mean	SD	CV %	Mean	SD	CV %
pH in water	6.2	0.4	6.4	6.2	0.3	4.84	6.4	0.3	4.67	6.5	0.2	3.06
OC (g/mg)	9.77	5.2	53.22	9.98	4.79	47.99	9.03	4.45	0.49	7.16	1.56	21.79
ECEC (cmol/kg)	7.77	4.97	63.96	5.07	1.14	22.49	4.71	0.47	9.98	4.62	0.44	9.52
B sat.	99.01	0.5	0.5	96.47	4.88	5.06	98.39	0.66	0.67	95.26	4.45	4.67
Mn (mg/kg)	238.6	19.74	8.27	231.5	13.23	5.71	178.75	8.54	4.78	155	10.02	6.46

Fe (mg/kg)	119	12.47	10.48	124.5	28.41	22.81	162.75	16.58	10.19	166.8	8.04	4.82
Cu (mg/kg)	1.06	0.05	4.72	1.07	0.06	5.61	0.99	0.15	15.15	1.1	0.09	8.18
Zn (mg/kg)	1.61	0.52	32.3	1.7	1.01	59.41	1.75	0.56	32	1.29	0.2	15.5
SD: Standard Deviation, CV: Co-efficient of Variation.												

Soils in mapping unit IHM-02 are classified as Typic plinthustulf (USDA soil taxonomy) and Petric plinthusol (WRB). It occupies 35.73% of the total study area. The parent material is sedentary, the land is well drained, lithology is banded gnesis and physiography position is hill crest. Soil samples were also taken from spatial designations with 0-30 cm depth at 20 m apart. Soil colour ranges from dark brown to brown with loamy sand texture. Soils in this mapping unit are slightly acidic. Values for co efficient of variation for micronutrients present in the soils from samples gotten from this mapping unit vertically and spatial include: Manganese; 5.71, 11.76 respectively, for iron; 22.81, 13.66 respectively, for copper; 5.61, 13.01 respectively, and zinc; 59.41, 78.09. Organic carbon ranges from low to high with mean values 9.98 vertically and 19.20 spatially. Cation exchange capacity is moderate with mean values of 5.07 vertically and 6.93 spatially. Base saturation is high with mean values for vertical and spatial designations of 96.47% and 99.25% respectively.

Soils in mapping IHM-03 unit are classified as Rhodic Plinthastalf (USDA taxonomy) or Petroplinthitc Lixisol (WRB). It occupies 8.66 % of the study area. The land is well drained, Lithology is banded gnesis and Physiographic position is hill crest. Soils in this mapping unit are slightly acidic, with a predominant texture sandy clay loam in the middle horizons. Values for the co-efficient of variation for micronutrient present in soils samples from this soil vertically and spatially include manganese: 4.78 and 0.39 respectively, iron: 10.19 and 10.10 respectively, copper: 15.15 and 6.92 respectively and zinc: 32.0 and 20.53. Organic carbon ranges from low to high with mean values of 9.03 and 19.04. Cation exchange capacity is moderate with values; 4.71 and 6.46, base saturation is high with values 98.39% and 99.07%.

The soil in mapping unit IHM-04 was classi ied as Kanhaplic Haplustalf (USDA soil taxonomy) or Haplic Lixisols (WRB) [9]. The Soils are well drained occurring at middle slope, they are Sandy clay textured soil, with yellowish brown colour with a mixture of pear shaped iron manganese concretions and quartz gravel occurring at depth of 100 cm. effective depth was 170 cm. Soils in this mapping unit are slightly acidic with values for co efficients of variation for micronutrients present vertically and spatially as follow: Manganese; 6.46 and 31.58 respectively, iron; 4.82 and 18.71 respectively, copper; 8.18 and 10.41 respectively, zinc; 15.50 and 29.46 respectively. Organic carbon ranges from moderate to high with mean values 7.16 vertically and 19.76 spatially. Cation exchange capacity is moderate, base saturation is high with values; 95.26% and 99.16% (Table 3).

Table 3: Spatial variability of micro-nutrients in soils of the study area.

Variables	Oshe series (Oxyaquic haplustalf)			Fashola series (Typic plinthustalf)			Temidire series (Rhodic plinthustalf)			Kishi series (Kanhaplic haplustalf)		
	Mean	SD	CV %	Mean	SD	CV %	Mean	SD	CV %	Mean	SD	CV %
pH in water	6.5	0.28	4.34	6.7	0.32	4.82	6.5	0.34	5.29	6.58	0.3	4.51

OC (g/mg)	20.33	5.18	25.5	19.2	14.28	74.38	19.04	7.68	40.34	19.76	19.17	17.02
ECEC (cmol/kg)	6.71	0.58	8.72	6.93	1.4	20.2	6.45	1.13	7.45	6.77	0.91	13.41
B sat.	99.25	0.06	0.06	99.25	0.14	0.14	99.07	0.39	0.39	99.16	0.21	0.21
Mn (mg/kg)	235	25.66	10.92	221.2	26.01	11.76	99.07	0.39	0.39	218.45	68.98	31.58
Fe (mg/kg)	152.9	19.76	12.93	157.9	21.58	13.66	140	4.14	10.1	150.45	28.15	18.71
Cu (mg/kg)	1.08	0.14	0.49	1.07	0.14	13.01	1.28	0.09	6.92	1.22	0.12	10.41
Zn (mg/kg)	1.71	0.49	28.8	2.88	2.25	78.09	2.7	0.55	20.53	2.71	0.8	29.46

The micro-nutrients Mn, Fe, Cu were observed to have low variability both vertically and spatially across the mapping units while Zn was found to vary moderately in IHM-01 and IHM-03 but high in IHM-02. The low variability of the micro-nutrients Mn, Fe, and Cu recorded indicates that these micro-nutrients are very much available and stable in the soil. The high variability observed with Zn in IHM-02 may be due to the physiographic position (hill crest) where these mapping units are located. Voss noted that the reason for high variability of nutrients is due to long term cropping which has removed measurable amounts of these nutrients, widespread use of animal measures which has decreased and also top soil has been removed through erosion.

Conclusion

The soils of this region are slightly acidic and tend towards neutral at which most plant nutrients are made available to plants. The soils were well supplied with micro-nutrients (Mn, Fe, Cu and Zn) with low variation both vertically and spatially across the soil types indicating a relative even distribution. However, soils of the humid tropics are subjected to intense minerallisation rates that causes rapid decline in soil nutrients after they were opened up for cultivation. It is advised that soils of this area should be properly managed to maintain its nutrient status and management should be site specific.

References

1. Memon M, Jamro GM, Memon NN, Memon KS, Akhtar MS (2012) Micronutrientavailability assessment of Tomato grown intaluka Badin, Sindh. Pak J Bot 44:649-654
2. Nazakat N, Nawaz MS, Cheema NM, Khan MA (2012) Zinc and Iron application to optimized seed yield of Mustard. Pak J Agric Res 25:28-33
3. Nazif W, Parveen S, Saleem I (2006) Status of micronutrients in soils of district Bhimber (Azad Jammu and Kashmir). J Agri Bio Sci 1:35-40
4. Warington K (1923) The effect of boric acid and borax on the broad bean and certain other plants. Ann Bot 37:629–672
5. Jemo M, Nwoke C, Pypers P, Vanlauwe B (2015) Response of maize (*Zea mays)* to the application of foliar fertilizers in the Sudan and Guinea savanna zone of Nigeria. J Plant Nutr Soil Sci 178:374-383
6. Akande SR, Lamidi GO (2006) Performance of quality protein maize varieties and disease reaction in the derived-savanna agro-ecology of South-West Nigeria. Afr J Biotechnol 5:1744-1748
7. Akano O, Modirwa S, Oluwasemire K, Oladele O (2023) Awareness and perception of climate change by small holder farmers in two agroecological zones of Oyo state Southwest Nigeria. Geo J 88:39-68
8. Saka JO (2015) Productivity and income potentials of intercrop combinations among food crop farmers in Southwestern Nigeria. Afr J Agric Res 10:4730-4737
9. Baiyeri KP, Eze SC, Onu EO (2012) Evaluation of Cassava (*Manihot esculentum Crantz)* Genotypes in Nsukka Agro-Ecology of Southeastern Nigeria. Agric Sci 11:64-70