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Research Article

Assessment of Selected Soil Micronutrients Status in Kwara State University Teaching and Research Farm, Malete, Nigeria

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Abstract

Field research was conducted to determine the availability and condition of soil micronutrients at the Teaching and Research Farm in Malete. The goal of the study is to assess the distribution and status of micronutrients and how they relate to a few key soil characteristics. A total of 173 soil samples were collected and compressed into 7 composite samples. Iron (Fe), Copper (Cu), Zinc (Zn), and Manganese (Mn) were the micronutrients determined in the laboratory using the Mehlich-III multi-nutrient extraction method. The particle size distribution (sand, silt, and clay), pH, and organic carbon of the soil were determined. The findings indicated that the soils of the teaching and research farm have a sandy loam texture, with sand concentrations of 80.64–82.64g/kg, silt at 6g/kg, and clay at 11.36–16.34g/kg. The results of the soil reaction revealed that the soils have minimal organic content (0.06-0.93g/kg) and are extremely acidic (5.1). The result of the soil micronutrients indicates that Fe content was high ((0.10-0.20mg/kg); copper was rated low (0.04-0.05 mg/kg); zinc was rated low (0.01-0.03 mg/kg) and manganese was also rated low (0.07-0.11mg/kg) respectively. The findings show that the key soil characteristics that affect the availability of micronutrients in the soil are sand particles, pH, and organic matter because of their substantial correlations. The highly substantial link between the investigated accessible micronutrients suggests that similar processes regulate both their availability and release to plants. Since the soils are suitable for the development of arable crops, additional applications of Fe-rich fertilizer won't be necessary, but a complementing supply of Fertilizers containing copper, zinc, and manganese is highly advised to improve the region's soil fertility.

Keywords: *Soil micronutrients, Soil fertility, Soil micronutrient fertilizers, Soil properties*

Introduction

The majority of macronutrients are recommended as fertilizers for crops in the nation; however, applying solely macronutrients continuously could hasten the depletion of other micronutrients nutrients. Although, micronutrients are required by plants in trace quantity, the role of micronutrients in balanced plant nutrition is vital, and information regarding their status in the most soils is insufficient. Micronutrients are important as counterparts to macronutrients often are associated with enzymatic activities of plants. Iron is essential for many important enzymes, including cytochrome that is involved in electron transport chain, synthesize chlorophyll. Copper is involved in several enzyme systems, cell wall formation, electron transport and oxidation reactions. Zinc is main building part of some enzymes and is needed for the plant enzymes formation; in addition, many enzymatic reactions active by zinc. Manganese plays an important role in oxidation and reduction processes, as electron transport in photosynthesis. Thus, micronutrient deficiency and/or toxicity can

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affect crop yield. Applying deficient micronutrients towards soil in conjunction with common fertilizers promotes crop yield (Bastein *et al.*, 2012) (Applying inadequate micronutrients to the soil together with conventional fertilizers increases crop output. Analyzing the micronutrients in the soil under various land-use regimes has become essential, particularly at this time when everyone is considering how Nigeria may diversify its economy through agriculture in light of the global decline in crude oil prices.

In addition to soil properties, land use pattern is a key factor in controlling the dynamics of nutrients and soil fertility. Due to continuous cultivation, soils under particular land use system may affect physio–chemical properties which may modify micronutrients content and their availability to plants. Evaluation of the physical, chemical and micronutrient state of the soil under various land use systems may be of major significance. Changes in the type of land use and how the soil is managed can have a significant impact on the physicochemical characteristics of soil (Wasihun *et al.,* 2015).

Information about the extent of micronutrient deficient areas as influenced by land use system is necessary for scientists, administrators, farmers and fertilizer manufacturers to determine the kind and quantity of fertilizer required for the particular region. According to Shehu *et al.* (2015) and Alemayehu *et al.* (2013), sustainable crop production in Nigerian soil requires a good understanding of the fertility status of the soil to impose appropriate nutrient management strategies. To implement effective nutrient management techniques, production in Nigerian soil requires a thorough understanding of the soil's fertility status.

The management techniques for sustainable food production will be aided by an awareness of the concentration of soil micronutrients as influenced by the system of land use, according to Gebeyaw (2015). But research on the micronutrient content of soils under land use regimes have not been completely examined in this study region and thus constituted the basis of our work.

A good knowledge of soils nutrients status and its reactivity is important for the realization of food security. With little to no focus on micronutrients, research has focused on the macronutrient status of teaching and research farms to establish their suitability for different arable crops. This objective of this study is to evaluate the nutrient status of Teaching and Research Farm in Malete. It will help to make appropriate recommendations for fertilization rates as well as the practice of proper soil management that will sustain arable crop production in this study area.

Materials and Methods

Experimental site

The Teaching and Research Farm at Kwara State University, Malete (KWASU T&R), which is situated in Kwara State's Moro Local Government Area, served as the study's experimental location. It is located eight kilometers north of the agricultural buildings and covers about 100 hectares. With a mean annual rainfall of roughly 1150 mm and a twofold maximum pattern between April and October, it is distinguished by distinct wet and dry seasons. The dry season starts in November and lasts until March, whereas the wet season starts in April and concludes towards the end of October. Additionally, the average yearly temperature is between 25 and 28.9^{0}C. The farm is located 360 meters above sea level in the Moro local government areas of Kwara State between Latitude 08^{0}71'N and Longitude 04^{0}44'E. The relief is very gentle. It is situated in the ecological Southern Guinea Savannah of Nigeria.

Geological development of the research area

The land area is a part of the Nigerian basement complex's South-Western zone of basement reactivation.

Vegetation and land use

The study area is predominantly used for the cultivation of arable crops such as maize, groundnut and cowpea, and perennial trees such as cashew and mango. The site also contains woody species such as baobab (*Adansonia digitata*), Neem tree (*Azadractha indica*) and acacia (*Acacia species*), grasses such as spear grass, elephant grass and Guinea gamba grass.

Field survey and sampling techniques

Based on landuse, the farm was separated into seven blocks. Using GPS to find those locations allowed us to collect field data and sample soil. The longitude, latitude, and elevation were noted for each point. Using a soil auger, the top surface (0–15 cm) of the soil was sampled.

Each study site had one transect put out along it, with the sampling points separated by 20 m (twenty meters). A measuring tape was used to measure points. These depths (0-15 cm) were chosen because Ogidiolu (2000) reveals that these are zones of active changes in the soil during cropping where roots of plants are concentrated. The distribution of micronutrients in the surface soil was also determined using these depths (0-15cm). A 100-ha land was divided into the seven blocks and the total sampling point was 173; crop museum (24), block 2A (32), block 2B (26), block 3A (33), block 3B (20), OFY (25), block 4 (13). In all, a total of 7 (seven) composite soil samples were prepared with proper mixing and Quartering, and the Global Positioning System (GPS) was used to determine the coordinates of the sampling sites. The samples from each sampling point were placed in polythene bags with the appropriate labels to prevent mix-ups before being transported to the laboratory to be air dried at room temperature, crushed, and put through a 2 mm sieve to determine specific chemical properties.

Laboratory analysis

Collected soil samples were air dried at room temperature, prepared with a 2 mm sieve and subjected to laboratory methods. Particle size analysis was done using the hydrometer method (Bouyoucos, 1962). The soil pH was determined electrometrically in water using a ratio of 1:1 (10 g soil: 10 ml distilled water), Total Nitrogen was determined using Kjeldahl digestion method. Exchangeable bases were extracted with 1M ammonium acetate (1M NH_4OAc) solution buffered at pH 7.0, as described by Anderson and Ingram (1993), Exchangeable acidity was determined by saturating the soil samples with potassium chloride solution and titrated with sodium hydroxide as described by Mclean (1965). Cation Exchange Capacity (CEC) of the soil was determined with 1M NH_4OAc buffered at pH 7.0 (Chapman, 1965; Rhoades, 1982), Using the atomic absorption spectrophotometer Buck scientific method GVP 210, the content of Fe, Mn, Cu, and Zn in the supernatant solution was determined and duplicate analyses of each sample were conducted.

Statistical analysis

The data obtained were subjected to discrete statistics and Pearson correlation coefficient was used to show relationship between soil micronutrients and a few chosen soil parameters

Results and Discussion

Physical and chemical properties of the study area

The results of soil physio-chemical characteristics and readily available micronutrients are shown in Tables 1 and 2. The findings indicated soils have sand content between 80.64 and 82.64 grams per kilogram, silt at 6 grams per kilogram, and clay at 11.36 to 16.34 grams per kilogram. The majority of the soil in this study region belongs to the sandy loam textural class. While the pH (1:1 KCL) ranged from 5.3 to 7.5, indicating somewhat strongly acidic to neutral qualities, the pH (1:1 H_2O) ranged from 6.5-8.4, indicating slightly acidic to moderately alkaline. Given that the total organic carbon ranges from 0.04 to 0.54%, the available phosphorus (3.36 - 10.36 mg/kg), showing that it is low while the total nitrogen (0.05 to 0.75%), the CEC (3.94-5.61cmol/kg) and the organic matter (0.06-0.93%), indicating that they are very low.

Available Iron (Fe) levels in the soil ranged from 0.10 to 0.20 mg/kg with a mean value of 0.125 mg/kg. The soils in the study area have high to moderate soil Fe content (0.1–10 mg/kg). This might be due to oxidation-reduction processes in the soil or the low pH contents. The status of Fe in soils and its availability is as a result of a complex set of factors related best to parent material, soil type, soil pH and climate. Cottenie (1981) reported that Nigerian soils derived from basic rocks such as basalt and amphiboles are richer in Fe than those derived from acid granites and sandstones and according to the ranges recommended by Amarcher *et al.* (2007) (Table 2) which might be brought on by how acidic the soils are. He also argues that low pH levels make iron (Fe) more accessible. This is also true for this study, where the pH value with the highest mean Fe content is the lowest.

The results of Dahar *et al*. (2014), who reported higher concentrations of Fe (4.55 mg/kg and 12.71 mg/kg), are not supported by our study. Although the amount of available Fe in tropical soils is often substantial, Enwezor *et al.* (1990) noted that there can occasionally be localized Fe deficiency. Soil has a sufficient amount of readily available Fe. However, a high concentration of Fe in the soil may cause the occurrence of plinthite and the buildup of complicated reactions that cause laterite to form. Once dry, it might permanently produce hard indurated minerals (ironstone), which might prevent root penetration and drainage. Mustapha *et al*. (2011) reported similar results which agree with these findings.

Available Copper concentrations in the soil range from 0.04 to 0.05 mg/kg with a mean value of 0.04 mg/kg (Table 2). 28 mg/kg of copper is often found in the earth's crust (Rudnick *et al.*, 2003). According to the classification of soil Cu as per the ranges (0-0.4mg/kg) provided by Havlin *et al.* (1999), these values (Table 2) are low. The soils were all discovered to be lacking in copper and it could be attributed to leaching of nutrients, low organic matter contents plus sandy nature of this soil. Kiran *et al.* (2017) found that sandy soils with low -organic matter is deficient in copper due to leaching losses. The study's findings show that all of the study sites had high sand and low levels of organic matter. However, as this study found, the main cause of this is leaching, which might result in an absence of undergrowth. Additionally, Foth and Ellis (1997) noted that soils with nearly bare surfaces from undergrowth appear to experience more serious losses of soil nutrients through leaching. Shuman (2005) observed that basic rocks and shales contain more copper than sands do in soils. The findings of (Haribhushan *et al*., 2013) noted a higher Cu mean value of 1.58 mg/kg, which this result contradicts. In contrast to the research region, which primarily consists of ferrallitic soils, the study by Haribhushan *et al*. (2013) was conducted on ferruginous soils. Similar to this, Nath *et al.* (2013) also found high Cu concentrations (14.96 mg/kg) in soils used for growing tea.

According to Rudnick and Gao (2003), the lithosphere has a zinc concentration of 67 mg/kg. It is most usually found as sphalerite and has a great affinity for combining with sulphide-ores (Menna, 2018). The results of the accessible zinc (Zn) content in soils at a depth of 0–15 cm are shown in Table 2. The range is 0.01-0.03 mg/kg, with a mean value of 0.02 mg/kg. This suggests that the soil is weak in Zn. According to the critical values of Esu (1991) (0.8–2.0 mg/kg), extractable zinc was given a low rating. The "Low status" soils would benefit from Zn fertilizer for increased yields of arable crops.

The Zn levels of soils of the study sites qualified for low status since they were less than 1 mg/kg, according to soil quality index values by (Amarcher *et al.*, 2007). The low Zn content may be due to trace element deficiency associated with the parent materials of Ferrallitic tropical soils, erosion and leaching as also observed by (Brady and Weil, 2007).

Moreover, the high sand, acid content and low organic matter of the soil (Table 1) may be other explanations for the low Zn content because (Tammam *et al.*, 2016) stated that low organic matter soils are generally poor in Zn especially in sandy soils.

Available manganese (Mn) ranges from 0.07-0.11mg/kg with mean value of 0.08mg/kg at the depth of 0 -15 cm, this indicates that Manganese is also deficient in the soil of the study area.

These values are low (Table 2) according to the classification of soil Mn as per the ranges between (1-10 mg/kg) suggested by Amarcher *et al.* (2007). The values of Mn as shown in Table 2, reveals that there is deficiency of Manganese in the different sites across the various depths. This deficiency may be as a result of low clay content as (Sharma *et al*., 2004) states that the higher the clay content of a soil, the greater will be the content of Mn. In the interaction between Mn and depth of the soil there was a reduction of Mn in the surface of the soils, this is suggestive of their relatively porous nature due to their high sand values.

Correlation coefficient of some micro nutrients and physico-chemical properties

The result of the correlation coefficient in Table 3 shows the relationship between available micronutrients and some physiochemical properties in Kwara State University teaching and research farms. Table (3) shows that Mn has a positive and significant relationship with Cu at 5% level of probability (r=0.761*). This suggests that Mn and Cu have a direct link, with Mn levels in the soil increasing as Cu levels increase.

Additionally, the correlation between clay and soil pH at the 1% level of probability is positive and substantial (r=0.888). This suggests a direct correlation between clay content and pH, meaning that the higher the clay content, the higher the pH. At a 5% level of probability, the link between N and Clay is significant and positive. This suggests that the amount of clay in the soil increases in direct proportion to soil nitrogen levels. Fe and organic carbon have an unfavourable and insignificant association. Fe exhibits a negative and non-significant relationship with organic carbon. This contradicts the results of Sidhu and Sharma (2010) and Kumar and Babel (2011) who reported that the available micro nutrients increased with increase in organic carbon but corresponds with decreased with increase in pH. However, because the soil's silt concentration is consistent throughout, it is impossible to calculate the correlation coefficient with another nutrient.

Conclusion and Recommendations

This study showed that in all the blocks investigated, micronutrients indicated possible deficiencies. In comparing the status of micronutrients in the KWASU T&R farm, this research revealed that soils possess the lowest mean values of Mn, Zn and Cu respectively. The general low availability of the micronutrients observed in all the blocks is a function of the high acidic contents as well as the deficient soil organic matter status of the soils. However, the studied soils contained moderate amounts of Fe content. The statistical analysis shows that there is no significant difference between manganese and copper. It further revealed that there is a direct relationship between clay and pH of the soil. This study demonstrated how important soil indicators, including sand, silt, clay, pH, organic carbon, and organic matter, regulate the availability of micronutrients. These soil parameters could be manipulated to combat any current or future deficiencies of micronutrients in these soils.

To increase the availability of soil micronutrient levels in the soils, it is strongly recommended to apply organic matter, and micronutrient fertilizers, such as copper sulphate, manganese sulphate, zinc sulphate, zinc oxide, and borax, together with macronutrient fertilizers like urea and NPK. The researchers should also use management strategies like low tillage, which will enhance soil fertility and keep micronutrient availability.

Declaration of competing interest

The authors have no relevant financial or non-financial interests to disclose.

Authors' contributions

This work was carried out in collaboration between all authors. Authors AKO designed the study, wrote the protocol,. Authors AKO and ORO anchored the field study and interpreted the data. Author AIA, managed the literature searches and produced the initial draft. All authors read and approved the final manuscript for publication.

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Table 1: Physical and chemical characteristics of sampled area

Sample No	pH 1:1 (H_2O)	pH 1:1 (KCl)	N %	Organic carbon %	Organic matter %	G %	Sand %	Silt %	Clay %	Texture	Ca++	Mg++ cmo/kg	Na++	K++	Acidity	Avai-lable. P mg/kg	EC.E.C.	Base saturation %
2A	8.4	5.3	1.75	0.39	0.67		80.64	6	16.34	S/L	2.47	1.08	0.49	0.65	0.8	9.31	5.49	85.43
2B	7	6.2	1.47	0.54	0.93		82.64	6	13.34	S/L	2.68	0.96	0.36	0.84	0.76	3.36	5.61	86.45
3A	6.5	5.3	1.05	0.19	0.33		82.64	6	11.36	S/L	2.11	0.78	0.27	0.76	0.74	7.49	4.66	84.12
3B	6.9	5.7	1.54	0.19	0.33		80.64	6	13.36	S/L	2.01	0.71	0.25	0.81	0.6	9.94	4.38	86.3
4A	6.7	5.8	1.61	0.36	0.62		80.64	6	13.36	S/L	1.96	0.48	0.27	0.63	0.6	10.36	3.94	84.77
Block 4	6.8	6.9	1.47	0.04	0.06		82.64	6	11.36	S/L	1.78	0.44	0.22	0.71	0.8	4.2	3.95	79.74
Crop Museum	7.4	7.5	1.54	0.04	0.06		80.64	6	13.36	S/L	2.01	0.38	0.24	0.62	0.84	5.81	4.09	79.46

Table 2: Status and distribution of micronutrient of the study area

Block NO	Fe (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	Mn (mg/kg)
2A	0.1	0.02	0.05	0.09
2B	0.11	0.03	0.04	0.07
3A	0.1	0.01	0.04	0.07
3B	0.08	0.03	0.04	0.08
4A	0.21	0.02	0.05	0.11
Block 4	0.18	0.02	0.05	0.08
Crop museum	0.1	0.01	0.04	0.07
Mean	0.125	0.02	0.04	0.08

Table 3: Correlation coefficient of some micro nutrients and physio chemical properties

correlation	Fe	Zn	Cu	Mn	PH	OC	Sand	Silt	Clay	Nitrogen
Fe	1									
Zn	-0.042	1								
Cu	0.719	0.000	1							
Mn	0.685	0.139	0.761*	1						
PH	-.347	0.000	0.293	0.089	1					
OC	-0.011	0.544	0.066	0.273	0.219	1				
Sand	0.082	0.082	-0.167	-0.517	-0.489	0.033	1			
Silt	a	A	a	a	a	a	a	1		
Clay	-0.272	0.242	0.266	0.351	0.888**	0.506	-0.667	A	1	
N	0.164	0.396	0.518	0.542	0.684	0.250	-0.891	A	0.781*	1

*. Correlation is significant at the 5% level (2-tailed).

**. Correlation is significant at the 1% level (2-tailed).

a. Cannot be computed because at least one of the variables is constant.