LONG TERM EFFECTS OF INORGANIC FERTILIZATION ON SOIL MICRONUTRIENTS CONTENTS IN A SAVANNAH ALFISOL

BY

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A FINAL YEAR PROJECT PRESENTED TO THE DEPARTMENT OF SOIL SCIENCE IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF AGRICULTURE DEGREE OF THE AHMADU BELLO UNIVERSITY, ZARIA NIGERIA.

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DECLARATION

I hereby declare that this project titled **"LONG TERM EFFECT OF INORGANIC FERTILIZATION ON SOIL MICRONUTRIENTS CONTENT IN A SAVANNAH ALFISOL"** has been written by me and that it is a record of my own research work. It has not been presented before in any previous provision for bachelors degree in Agriculture in this university and sources consulted are clearly indicated in the reference.

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CERTIFICATION

This project entitled "**LONG TERM EFFECTS OF INORGANIC FERTILIZATION ON SOIL MICRONUTRIENTS CONTENTS IN A SAVANNAH ALFISOL"** by John Ushie Felix meets the requirements governing the award of the bachelor of Agriculture of Ahmadu Bello university Zaria, and it is approved for its contribution to knowledge and literacy presentation.

JOHN USHIE FELIX — Date

Student

DR. NAFIU ABDU — Date

Supervisor

DEDICATION

I dedicate this work to Almighty God who has given me the grace to make it a success, to my parent, Mr. and Mrs. John Ushie Uminya, my brothers, Chris, Peter, Emmanuel, Job, God's gift, and Miracle.

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ABSTRACT

The available micronutrients (Cu, Zn, Fe, Mn) contents of soil that have received Dung-D and inorganic fertilizers (containing N, P, K) for 45 years and thereafter fallowed for 15 years were extracted using 0.1N HCl. The mean values of silt and clay were higher in the control plot (46.635% silt and 21.865% clay) than other treatments. Soil pH indicated strongly acidic condition ranging from 5.40-6.20 in water and 4.7-5.3 in $CaCl_{2.}$ Micronutrients content was highest in the control plot while the fertilizer treated plots were deficient in the micronutrient especially Cu and Zn. Correlation analysis showed that Cu correlated with soil pH and silt correlated with Zn. Relationship among the micronutrient show that only Mn correlated significantly with Zn.

CHAPTER ONE

1.0 INTRODUCTION

Extensive research carried out on plant nutrition established the essentiality of 16 elements, out of which C,H and O are termed structural elements, N, P and K are termed major elements and Ca, S and Mg are referred to as secondary elements in terms of fertilizer requirement. The remaining seven Viz; B, Mn, Zn, Mo, Fe, Cu and Cl are needed in smaller amount and are regarded as trace element or micronutrients (Kanwar and Randhawa, 1967).

More so, micronutrient are as essential as macronutrient despite their low requirement by plants they still play significant roles in both animals and plants functions, especially for plant physiological functions as part of the structural components or activators of specific enzymes in bacterial cells. Essentiality connotes that deficiency symptoms can only be corrected by the nutrient element in question (Agbenin and Felix-Heningsen, 2001). However at high concentration they are toxic to soil microorganism and plants resulting to crop and yield decline (Oliver, 1997). Furthermore, other trace element like selenium (Se), cadmium (Cd),nickel (Ni), mercury (Hg), lead (Pb), and chromium (Cr) have toxic effect on living organisms and are often regarded as contaminant and therefore not essential for plant nutrition (He et al., 2005).

Soils of the Northern Guinea Savannah (NGS) of Nigeria are weathered ferruginous soil classified in soil taxonomy as Alfisol (USDA Soil Survey staff, 1995). These soils are relatively leached and are mainly formed under forest and have a subsurface horizon in which clays have accumulated. Alfisols are primarily found in temperate humid and sub humid regions of the world. Most of these soils have low intrinsic fertility making the need for fertilizer input unavoidable especially with intensive cultivation (Richard, 1975). This implies that under continuous cultivation without replacement of exported nutrients, nutrient budget can further be negative without sufficient input by equilibrated fertilizer or other sources of soil nutrients (Braun, 1995; Wijanida, 1996). The increase in population and the consequent extension in the demand for food have to an extent eliminated the indigenous traditional methods of soil amendment and fertility maintenance practiced by farmers in this region i.e. bush fallow, shifting cultivation etc. This in-turn has increased the use of inorganic fertilizer as a major source of nutrient by indigenous farmers to boost food production to counter the geometric growth progression. Furthermore, the accompanied change in soil management practices frequently alters micronutrients availability. However, the continuous use of inorganic fertilizer by farmers has been aided by its relative ease of application and quick results (Fawole et al., 2010). The DNPK experimental site is a perfect match for this research as it was established to compare the effectiveness of inorganic fertilizer with or without dung in maintaining soil quality and crop yield under continuous cultivation. The objectives of this research were:

1. To access the impact of long-term fertilization on soil micronutrients (Zn, Fe, Cu, and Mn) in a typical savannah Alfisol.

2. To quantify their status (soil micronutrient) and investigate their relationship with soil properties.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 IMPORTANCE OF MICRONUTRIENTS

The importance of micronutrient cannot be overemphasized; they are known to form stable complexes with the naturally occurring ligands in plant metabolic system. They are also known to initiate the formation of vegetative growth and hence the yield of crops (Mortved et al., 1972). The deficiency of these element always result in the attendant consequences of growth cessation or retardation and wilting of plant hence low or poor crop productivity. More so, in general farmers only apply micronutrient when crops show deficiency system while micronutrient deficiencies decreases yield before symptoms appear.

However of all micronutrient iron (Fe), is required in greater amount compared to Zinc (Z), Manganese (Mn) and copper, while Fe and Mn are found mostly in acid soils (David et al., 2005). Copper is a component of some enzymes and of vitamin A. Symptoms of copper deficiency include browning of leaf tips and chlorosis. Iron is essential for chlorophyll synthesis which is why an iron deficiency results in chlorosis. Manganese activates some important enzymes involved in chlorophyll formation. Manganese deficiency results in chlorosis between the veins of leaves. Zinc participates in chlorophyll formation and also activates many enzymes; symptoms of zinc deficiency may include chlorosis and stunted growth.

2.2 Micronutrient status of soil in the Nigerian Savannah

Although information on soil micronutrients status of Nigeria savannah is scanty, investigations have revealed micronutrient deficiency in some Nigerian savannah soil Lombin (1983a, 1983b, 1985a). On a global study Sillanpaa (1982) reported generally low to deficient levels of B, Cu, Mn and Zn and normal to excessive levels of Mn in a number of soils from Nigeria Savannah. Zinc had been reported to be generally of low mobility in soils (Chesworth, 1991) and has a tendency of being absorbed on clay size particles (Sims and Johnson, 1991, Alloway, 2008).

Oyinlola et al (2010) inferred that some Northern Nigeria Savannah soils are deficient in Zn. However, Yaro et al (2002) reported adequate levels of available zinc. Lombin (1983a) had earlier reported that the contents of available Cu in soils of northern Nigeria Savannah are adequate and poses no fertility problems. However, this in contrast with the result of Sillanpaa (1982) who reported generally low to deficient levels of Cu in some Nigerian soils. Although available Fe is generally high in tropical soils, localized deficiencies of Fe are known to occur Enwezor et al (1990). The average content of Fe in rocks has been estimated as 5% in igneous rock, 4.1% in shale, 1% in limestone (Rankama and Sahara, 1950). Lombin (1983a) had reported that the northern savannah soils which are predominantly mildly to medium acid seem well supplied with Mn at present and the prospect of deficiency problems in the foreseeable future seems remote. High value of Fe and Mn could be due to acid condition of the soil.

2.3 Micronutrient forms and cycling in the soil

Metals exist in one of four forms in the soil: mineral, organic, sorbed or dissolved (Clain and Jeff, 2003). Majority of metals in soil are bound mineral and organic matter and are unavailable to plants. Sorbed metals represent the third largest pool, and are generally very tightly bound to soil surfaces. (Clain and Jeff, 2003)

Although mineral, organic, sorbed metals are not immediately plant available .They can slowly release metals into solution.

Micronutrients in the soil include:

Iron

It is taken up by plant as either Fe^{2+} (ferrous cation) or Fe^{3+} (Ferric cation). Iron cycles both mineral and organic forms. It may exist in the soil solution, includes soluble iron and organic matter complexes in the form of chelate. Chelation occurs between soluble organic compounds and certain metals in the soil through processes involving microorganism (Tai McClellan, 2007). Chelates play important role in micronutrient management because chelation increases the solubility and plant uptake of many micronutrients, as primary minerals and at cation exchange site and soil particles. Fe containing minerals dissolve to replenish the soil solution as Fe is removed by plants (Tai McClellan, 2007).

Manganese

The primary form of manganese uptake is Mn^{2+} (Manganous ion).The manganese cycle is similar to the iron cycle. Manganese cation in soil solution includes manganese and organic matter complexes known as chelates (Tai McClellan, 2007) including exchangeable manganese on soil particles, primary and secondary manganese-containing minerals and soil organic matter. Manganese may undergo precipitation/dissolution, sorption/desorption on the CEC, mineralization, and chelation (Tai McClellan, 2007).

Zinc

Zinc ion (Zn^{2+}) cation is the predominant form taken up by plants. Zinc cycling includes: Zinc cation in soil solution, soluble zinc and organic matter complexes known as chelates, Zinc retained by soil particles on the cation exchange sites, primary and secondary zinc-containing minerals and soil organic matter (Tai McClellan, 2007). Zinc bearing minerals can dissolve and supply zinc to the soil solution. On in the soil solution, zinc can be immobilized, taken up by plants, retained by soil particles, or chelated with soluble organic matter. Organic matter zinc must undergo mineralization before it becomes available for plant uptake (Tai McClellan, 2007).

Copper

Copper is taken up as Cu^{2+}. Like zinc , the copper cycle includes: solution copper which include soluble copper and organic matter complexes known as chelates, the copper cycle includes also exchangeable copper on the cation exchange sites of soil particles , primary and secondary copper minerals (copper may be occluded, buried , within the structures various minerals, such as iron and aluminum oxides (Tai McClellan, 2007).

Copper cycle also includes organic copper; copper may be more tightly bound to organic matter than the other micronutrients though copper deficiencies can occur in organic soils. Copper –containing minerals can dissolve and supply Zn to the soil solution. Like zinc, copper can be immobilized by microorganisms, taken up by plants, or exchanged on soil particles surfaces (Tai McClellan, 2007).

Copper may also form chelates with soluble organic matter. Organic copper must be mineralized before it is available for plant uptake (Tai McClellan, 2007).

2.4 Factors affecting micronutrient availability

SOIL pH

Most Fe deficiencies occur in calcareous soils, high H soils especially in arid areas (Clain and Jeff, 2003). High pH also affects Zn, Mn availability since its precipitate at high pH. Cu availability decreases as pH increases, primarily due to decreased solubility of Cu minerals. Excessive liming can induce micronutrient deficiencies (Tai McClellan, 2007).

SOIL MOISTURE AND AERATION

Poorly aerated soils with excessive moisture in calcareous soil can promote iron deficiencies. However, flooding of non-calcareous soils can improve iron availability (Tai McClellan, 2007). On the other hand high soil moisture and poor aeration increases the availability of Mn due to an increase in solubility. Dry weather increases Mn deficiency likely due to precipitation of unavailable Mn oxides. Flooding generally decreases Zn availability (Tai McClellan, 2007).

ORGANIC MATTER

Organic matter improves iron, zinc and manganese availability due to chelation, which increases iron solubility. Addition of manure can increase chelation. Copper forms tight bond with organic matter, which may reduce it availability in organic (peat and muck) soils (Tai McClellan, 2007).

CLIMATE

Under wet condition and warm temperature Mn availability increases though cool wet weather have negative effect on Zn availability. However increasing soil temperature increases Zn availability (Tai McClellan, 2007).

INTERACTION WITH OTHER NUTRIENTS

Excessive amounts of other micronutrients can decrease the availability a particular micronutrients (Tai McClellan, 2007).This can occur as a result of antagonistic effect of one element on the other.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 STUDY OF LOCATION AND SOIL SAMPLING

The sampling site is the long-term Dung, Nitrogen, Phosphorus and Potassium (DNPK) experimental field located behind the National Agricultural Extension

Research and Liaison Services (NAERLS) ABU, Samaru, Zaria ($11^0$11'N, $07^0$38E) in the sub-humid northern guinea savannah at an altitude of about 686m above sea level. The trial started in 1950 and it is the oldest organic and mineral fertilizer experiment in West Africa. In the first decade of the trial (1950-1960), cotton, sorghum and groundnut were cropped in rotation while between 1961 and 1970, cotton monoculture dominated from 1976, a rotation of groundnut and maize became a predominant cropping pattern. Nitrogen was usually not applied when groundnut is grown as a sole crop. In 1967; lime was applied on a plot by plot basis depending on the actual lime requirement of each plot. Also, micronutrient like zinc (Z), molybdenum (Mo), boron (B), copper (Cu) were sprayed on the crop growing on that field at that same year. The trial has been under natural fallow since 1997. The DNPK plot consists of 81 plots with a length of 272.25m and width of 90.53m. The sample were taken from 5 plots which constitute the treatments, plot 3 which was under N application, plot 14 under control, plot 32 under P application, plot 64 under K application and plot 78 which was under N, P, and K application. The samples were taken at (0-15 cm) depth and each was replicated three times. The soil samples were air dried and passed through a 2-mm mesh sieve and stored prior to analysis. A summary of the characteristic of the sampling site is given in Table 1 below.

3.2 LABORATORY ANALYSIS

3.2.1 Particle size distribution

The hydrometer method was used in determining particle size distribution. 50g of a 2mm sieved soil was transferred into a plastic tube and?? Of sodium hexametaphosphate (calgon) was added to the soil and shaken for 5 minutes using a mechanical shaker. The suspension was poured into a 1000ml glass cylinder and made to mark. The suspension was thoroughly stirred using a plunger and hydrometer was inserted.

Readings were recorded at exactly 40 seconds and after 2 hours and the blank of the reagent was also run. The USDA textural triangle was used to determine the textural class (Gee and Bauder, 1986). The percentage of sand, silt and clay were determined using the formula:

$$\%Clay = \frac{\text{Corrected 2hours reading -blank}}{\text{Weight of soil}} \times 100$$

$$\%\ Silt = \frac{\text{Corrected 40seconds reading - blank}}{\text{Weight of soil}} \times 100$$

Corrected reading = (Actual reading –blank) + 0.36T

Where T =Temperature

3.2.2 pH

10g of air dried 2mm sieved soil sample was measured into a 50ml plastic beaker and 25mls of distilled water was added, to another set of plastic beakers 25ml of $CaCl_2$ was also added and stirred. The samples were allowed for 15 minutes before stirring again to stand for another 15 minutes after calibrating the pH meter with 2 buffer solution pH 4 and pH 7. The pH was measured by inserting the electrode of the pH meter into the partly settled suspension.

. 3.2.3 ORGANIC CARBON

The organic carbon was determined by Walkley Black wet oxidation method as described by Allison (1965). 1g of the soil was digested with 1N potassium dichromate ($K_2Cr_2O_7$) solution for 20 minutes using concentrated sulphuric acid (H_2SO_4) to facilitate the reaction by heat generation. After cooling 100mls of distilled water was added and organic carbon was determined by titration with 0.5N ferrous sulphate solution to a red (maroon) end point. Organic carbon was calculated using the following formula:

$$\%O.C = \frac{(B-T) \times 0.003 \times M \times F \times 100}{\text{Weight of soil}}$$

Where;

m = Normality of $FeSO_4$

F= correction factor (1.33)

(Black, 1965)

3.2.4 TOTAL NITROGEN

1g of the soil sample was weighed into a digestion tube to which about 2g of $CuSO_4$ catalyst and 10mls of sulphuric acid was added. The mixture was digested for about 3 hours to obtain a clear solution which was allowed to cool before transferring into a 100ml volumetric flask and distilled water was added to mark. 10 ml of 2% boric acid and 3 drops of indicator was added into the flask. 10 ml of the aliquot was transferred into a distillation flask. The flask was attached to a distillation chamber and 10 ml of NaOH was also added into the distillation flask containing the aliquot. The NH_3 was distilled into the aliquot/ indicator receiver flask until 50 ml was collected. The distillate was titrated with a standard 0.025N H_2SO_4 to a pink end point. Calculation of total N was done using the formula:

$$\% N = 0.025 \times 0.014 \times 10{,}000 \, (T-B)$$

Where,

N= Nitrogen, T= Titer value, B= Blank

3.2.5 TOTAL PHOSPHORUS (TOTAL P)

0.2g of soil and 20mls of ternary (Nitric acid-HNO_3, Perchloric acid-$HClO_4$, Sulphuric acid-H_2SO_4) acid were measured into a conical flask. The mixture was digested for one hour so that the resultant clear solution was transferred into a 25mls flat bottom flask and made to mark using distilled water and allowed to stand for 15 minutes. 2mls of developer alongside 5mls of aliquot/digest and 3mls of distilled water were added into a plastic vial. This was allowed to stand for 15 minutes for colour to develop; the absorbance was measured using a colorimeter.

Total P was calculated using this formula:

$$\text{Total P} = \frac{DF \times G \times R \times EV}{\text{Wt of soil} \times \text{Aliquot taken}}$$

Where R = Reading from the spectrometer, G = Gradient,

DF = dilution factor, EV = Extraction volume/ volume of digest.

3.2.6 AVAILABLE PHOSPHORUS

1g of the soil sample was measured into centrifuge tube with 7 ml of the extractant solution added and shaken for one minute. The soil samples were then centrifuged for 5 minutes. 4 ml of developer was added into a clear vial plus 5 ml of the clear supernatant solution and made to 25ml using distilled water. The available phosphorus was measured using spectrophotometer. Calculation for available phosphorus was done using the formula:

$$\text{ppm or mg/kg} = \frac{DF \times EV \times G \times R}{\text{Weight of soil}}$$

3.2.7 EXCHANGEABLE BASES

1g of air dried 2mm sieved soil samples were weighed into a 50ml centrifuge tube. 2ml of 1N NH_4OAC solution was added and the suspension was then centrifuged for 30 minutes. The soil suspension was then filtered using a Whatman No. 1 filter paper. The filtrate was then divided into 2 equal portions; one portion was used for the determination of Ca and Mg by EDTA method while the other portion was used for the determination of K and Na using a flame photometer.

3.2.8 EXCHANGEABLE ACIDITY 1-N KCl SOLUTION METHOD

10g of air-dried 2mm sieved soil samples were weighed into a funnel fitted with a Whatman filter paper. The soils were then leached with 100mls of 1N KCl solution using small aliquots (10mls) in not less than 2 hours. The leachates were collected in a 100ml volumetric flask, made to volume with KCl and mixed well. After mixing 50mls of the leachates were pipetted into a 250ml beaker. 5 drops of phenolphthalein indicator was added and leachates were then titrated with 0.1N NaOH to a permanent pink end-point. The amount of 0.1N NaOH used was recorded and corresponded to Cmol (Al+H). The CEC was determined by summation method.

3.2.9 EXTRACTION PROCEDURE FOR MICRONUTRIENTS

In this case 2g of soil sample was measured into a plastic tube and 20 ml of 0.1N HCl extractant solution was added also and shaken for 30 minutes using a mechanical shaker and centrifuged for 5 minutes so that a clear supernatant solution was obtained. The Atomic Absorption Spectrophotometer (Pye unicam model 172) was used to measure the Fe, Cu, Zn and Mn content of the extracts.

3.3 STATISTICAL ANALYSIS

The mean values and standard deviation of means of the physical and chemical properties of the soils were computed. Single correlation analysis was run to show relationship between micronutrients extracted by HCl extraction method and also with soil properties using SAS statistical package version 9.1.

CHAPTER FOUR

4.0 RESULT AND DISCUSSION

4.1 Physical properties

The data on the physicochemical properties of the soil are given in Table 1. The control plot has the highest organic carbon, Mn and Zn contents with values 1.038g/kg, 9.81g/kg, 1.44g/kg respectively as well as silt and clay contents with values of 46.6% and 21.9% respectively. The soil pH values are generally low, indicating strongly acidic condition; the pH values were 5.4-6.2 in H_2O and PH 4.7-5.3 in $CaCl_2$ with value of 5.91 and 5.04 in H_2O and $CaCl_2$ respectively. The texture of the soil ranged from sandy loam to loam. The organic carbon content which ranged from 0-1.736 fell within the extremely low or almost not detected levels to deficient levels and the total N content with range of 0.088-0.508% is quite adequate in the soils. Jones and Wild (1975) had earlier reported low levels of organic carbon, available P and total N in Nigerian savannah soil. The CEC of soils were generally low and ranged from 3.69-10.67. Most soil samples have ECEC higher than the critical value of 4.0cmol/kg needed to retain most cations against leaching in the highly weathered sandy soils (Sanchez, 1976).

Table 1. Mean value of the physico-chemical properties of the different plot.

Parameter	P-Plot	N-Plot	K-Plot	NPK-Plot	C-Plot	Means
SAND(g/kg)	42.97	38.48	58.23	43.22	32.56	43.844
SILT(g/kg)	40.707	44.993	29.603	37.540	46.635	39.414
CLAY(g/kg)	16.110	16.527	12.170	19.240	21.865	16.848
pH(H_20)	6.100	5.767	6.067	5.567	6.150	5.914
pH($CaCl_2$)	5.200	4.833	5.200	4.800	5.250	5.043
CEC(Cmol/kg)	5.273	6.367	5.673	5.787	6.140	5.827
O.C%	0.426	0.405	0.505	0.539	1.038	0.550
TOTAL P(g/kg)	67.600	50.700	41.600	65.000	54.600	55.993
AVAIL P(mg/kg	15.210	5.293	4.937	9.550	2.445	7.847

TOTAL N(g/kg)	0.298	0.181	0.280	0.333	0.245	0.269

Textural class ranged from sandy loam to sand

4.2 Zinc

The HCl extractable Zn (mg/kg) of the different plot varied slightly with mean values of 1.047, 1.10, 0.897, 0.854 and 1.144 for P-plot, N-plot, K-plot, and NPK-plot and the control plot respectively with the control plot having the highest Zn content. Generally, the available Zn obtained from this study fell far below the critical level of 3.3mg/kg for HCl extractable Zn reported by Pam (1990).

4.3 Iron

The soils have more Fe content than other micronutrient with mean values of 4.98mg/kg, 6.26mg/kg, 5.92mg/kg, 10.38mg/kg and 9.72mg/kg for plot-P, plot-N, plot-K, plot-NPK and control plot respectively. The plot that received NPK treatment has the highest Fe content with mean value of 10.38mg/kg. The content of available Fe in the soil is not very adequate though above the critical range of 3.0-4.5mg/kg (Sillanpaa 1982) for extractable Fe. The result obtained from this study correspond to that of Kang and Osiname (1972) who reported that Fe deficiency is unlikely in acid soils. Deb and Sakal (2002) had reported critical range of 0.1N HCl extractable Fe as 2.5- 5.8mg/kg. Although available Fe is generally high in the tropical soil localized deficiencies of Fe are known to occur (Enwezor et al., 1990). From the result obtained however, it is possible that under continuous intensive cultivation Fe is likely to become deficient in this soil.

4.4 Copper

The mean values of available Cu content in mg/kg varied from 0.049, 0.028, 0.042, 0.036 and 0.06 for the P-plot, N-plot, K-plot, NPK-plot and control plot respectively with the control plot having higher available Cu content. These values are far below the range reported by Kparmwang et al (1998) and Yaro et al (2002) and also far below the critical values of 2.0mg/kg for HCl-extractable Cu, as recommended by Sims and Johnsons(1991).This indicates that Cu exist in highly deficient and almost not detected levels in the soils.

4.5 Manganese

The available Mn content of soils varied with mean values of 5.273mg/kg, 6.367mg/kg, 5.673mg/kg, 5.787mg/kg and 6.140mg/kg for the P-plot, N-plot, K-plot, NPK-plot and control plot respectively, with the control plot repeatedly highest in the Mn content. The least value of available Mn was found in the NPK plot. The values of available Mn obtained from this study were lower than those reported by Kparmwang et al (1995) although available Mn in the soils are above the critical range of 1-4mg/kg as recommended by Sims and Johnson (1991).

4.6 Relationship between micronutrient and selected soil properties

The Cu content correlated strongly with soil pH with r values of 0.721 and 0.778 in water and $CaCl_2$ respectively (Table 2). This result is in agreement with Oyinlola (2010) and Kparmwang et al (1998) who had earlier reported significant correlation between HCl extractable Cu and pH in similar soils. This showcases the importance of pH to micronutrient availability in the soil. Fe did not correlate significantly with soil properties this is similar to what was reported by Yaro et al (2002). Silt however correlated positively with Zn content. This is in agreement with the report of Oyinlola et al (2010) who also reported significant positive correlation between silt and Zn. Mn also did not correlate significantly with any soil property. Surprisingly there was no correlation between clay and Fe, Cu, Zn, Mn content. This suggests that the clay had little or no influence on the availability of the micronutrients. This could be attributed to the parent material and the very low organic carbon content of the soils.

Table-2. Relationship among micronutrients and soil properties of the tested soil samples for the different plot.

Properties	Fe r and p value	Cu r and p value	Zn r and p value	Mn r and p value
Soil pH(H_20)	- 0490, 0.075	0.721, 0.0036*	0.416, 0.139	0.355, 0.213
Soil pH($CaCl_2$)	-0.363, 0.202	0.778, 0.001**	0.231, 0.139	0.165, 0.572
OC	0.348, 0.223	0.411, 0.144	0.176, 0.547	0.219, 0.453
CEC	0.084, 0.776	-0.099, 0.737	0.098, 0.738	0.162, 0.580
SAND	-0.212, 0.467	-0.086, 0.770	-0.387, 0.171	-0.317, 0.269
SILT	0.115, 0.695	0.066, 0.824	0.546, 0.043*	0.466, 0.093
CLAY	0.336, 0.241	0.133, 0.652	0.149, 0.612	0.109, 0.712

** 1% Significant * 5% Significant

4.7 Relationship among micronutrient

The result of the correlation among the micronutrient is shown in Table 3. All the micronutrient did not correlate significantly with one another except for Mn which correlated significantly with Zn at 1% level of significance. Buckley (1989) had earlier reported that the surfaces of secondary oxides of Mn control the behavior of certain trace element by adsorption and specifically that Mn coating on elastic particles attract Cu and Zn among others. The significant relationship between Mn and Zn implies that the availability of the micronutrients is controlled by similar pedogenic processes or factors Kparmwang and Malgwi (1997).

Table 3. Correlation among micronutrient showing r value

	Fe	Cu	Zn	Mn

Fe	-----	0.085	-0.257	-0.170
Cu		------	0.285	0.149
Zn			-------	0.920**
Mn				------

** 1% Significant * 5% Significant

CHAPTER FIVE

CONCLUSION

Result obtained from this study has shown that Mn and Fe are relatively adequate as compared with Cu and Zn content which were highly deficient in all the plots. The check plot which was consistently high in the amount of micronutrient underscores the effect of inorganic fertilization on soil micronutrient content and upholds the advantage of land fallow on soil quality improvement and also suggests augmentation with organic fertilization for better soil quality improvement. The correlation between the micronutrients with pH and silt content shows that these factors affect their availability in the soils. More so the correlation among micronutrients i.e. between Mn with Zn shows the micronutrient availability is affected by the same pedogenic factors.

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