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IMPACT OF TOPOSEQUENCE ON SOIL MICRONUTRIENTS IN TULA, KALTUNGO LOCAL GOVERNMENT AREA, GOMBE STATE, NIGERIA

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ABSTRACT

Micronutrients are element need in small amount but its deficiency can lead to a major constraint to soil productivity. Toposequence plays a major role in influencing soil fertility distribution. This study aims at assessing the effect of toposequence on soil micronutrients in Tula. Soil sample were collected from upper, middle and lower slope at the depth of 0-15 cm and 15-30 cm and analyzed for DTPA-extractable micronutrient using standard procedures. The soils were all rated very high in iron (Fe), Manganese (Mn), Copper (Cu) and Zinc (Zn) contents. The results shows mean Fe values in the lower slope was24.1 mg/kg, middle slope was 16.0 mg/kg and upper slope was 9.9 mg/kg and subsoils were significantly ($p < 0.01$) higher than surface soils. The mean Mn values in the lower slope was20.6 mg/kg, middle slope was 17.5 mg/kg and upper slope was 14.2 mg/kg. The mean Cu values in the upper slope was 4.2 mg/kg, middle slope was 3.9 mg/kg and lower slope was 3.76 mg/kg. The mean Zn values in the lower slope was 4.2 mg/kg, middle slope was 3.9 mg/kg and upper slope was 3.76 mg/kg. Extractable Zn in subsoils were significantly ($p < 0.001$) higher than surface soils. Extractable Fe and Mn increase down the toposequence while Cu and Zn decreases down the toposequence. All the micronutrients increased with soil depth. The toposequnces were all adequate in micronutrient but there are possibility of micronutrient toxicity which call for caution for sustainable development.

Key words: Toposequence, Micronutrients, Gombe, Savannah

1.0 INTRODUCTION

Information on soil micronutrient status of northern Nigeria savanna soils is scanty. Investigations carried out so far have revealed micronutrient deficiency in some Nigerian savanna soils (Enwezor *et al*., 1990; Oyinlola and Chude, 2010; Jimoh *et al*. 2015). Micronutrients are needful elements for normal growth of plants, that are needed at little amount (Fageria, 2007), If these elements are insufficient, plants may suffer from physiological stresses caused by inefficiency of several enzymatic systems and other related metabolic functions (Baybordi, 2006). The deficiency of micronutrients has become a major constraint to productivity, stability and sustainability of some Nigerian savanna soils (Sadiq *et al*., 2008; Ibrahim and Abubakar, 2013). Low levels of available Zn and B have been reported in soils of northern Guinea savanna (Enwezor, *et al*., 1990; Oyinlola and Chude, 2010).

The transformation from the fallow and shifting cultivation practices prevalent among farmers to intensive continuous cultivation of soils and the use of improved crop varieties which take up many nutrients from the soil are major causes of deficiency of these micronutrients. In addition to this, the current fertilizer recommendation for crops in Northern Nigeria is only for macronutrients; continuous application of one or two macronutrients may in due course deplete the soil reserve of other nutrients and limit the crop performance (Oyinlola and Chude, 2010).

In order to enhance the micronutrient status of these soils, there is need for assessment of their initial micronutrient status in order to integrate the appropriate soil fertility management that involves judicious use of combined organic and inorganic fertilizers. This is a feasible approach which has been employed in overcoming soil fertility constraints (Abedi *et al.*, 2010). Also the information about the extent of micronutrient deficient is area necessary for the scientists, administrators, farmers and fertilizer manufactures to determine the kind and quantities of fertilizer required for the particular region (Yadav, 2011). This study was aimed at assessing the effect of toposequence on soil micronutrients in Tula with the view to improve soil fertility management and productivity.

2.0 MATERIALS AND METHODS

2.1 Study Area

Tula is located in Gombe south, Gombe state, covering latitude 11° 75′ 55" *to* 19^0 34' 48'' N and longitude 11° 59′ 34 '' to 11° 34' 60" E (figure 1). It shared boundary with Ture/kaltungo in the west, panda, kamu, and waje in the north east. Tula settlements are in a plateau area with 645 meter above sea level and are rich in agricultural land on the plain of Baule and Yiri as well as high tourism potentials in Wange. The climate of the study area according to Koppen climatic classification is within the AW type of climate. It is seasonally wet and dry having an average annual rainfall regime from 850 mm to 1000 mm. The rain fall is concentrated between May and October within a single maximum in July/ August (Kowal and Knabe, 1972). The area is developed on crystalline basement complex bedrock. Sedimentary formation underlies much of the area during the late craterous period, which has influenced the topography of the area. The soil and vegetation in Tula is different from its neighboring villages due to the nature of the topography. The soils are fertile especially on the lowland as a result of transportation and deposition of nutrients down slope. The vegetation of the study area comprises of a light close canopy, with spindling of under shrubs and sparse growth of grasses to a more open grass lessee's height as a result of the presence of scattered rocks round the area. Major tress in the study area includes neem tree, bamboo tree, baoba tree tamarineindoca, gorontula trees and others.

2.2 Experimental Procedure

A slope portion in the study area was selected for the purpose of assessing the impact of different slope classes on soil properties in the study area. Upper, middle and lower were marked using ranging poles at interval of 30 m along each slope classes. The center of each slope class, slope angle was measured using Abney level. Each slope classes was sub-divides it into two (2), making a total of six (6) sub-classes from which soil samples was collected. Soil samples was collected from the six (6) segments at a depth of 0-15 cm and 15-30 cm using soil auger. The soil sample of each slope class at 0-15 cm was mixed thoroughly together as well as those at 15-30cm in other to obtain composite sample. A total of six (6) samples ware taken for laboratory analysis.

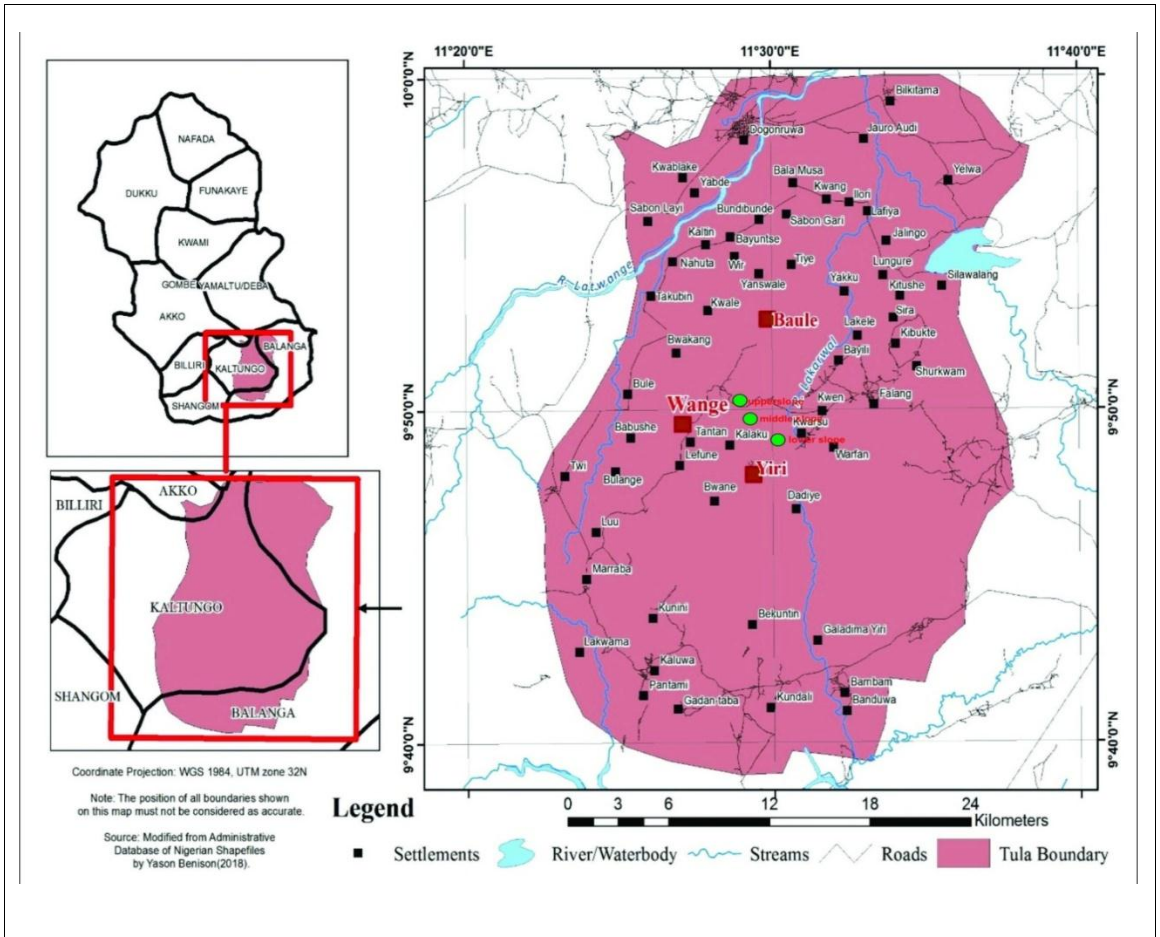

Figure: 1Map of the study area showing the sample points

Source: Modified from administrative map of Gombe, Nigeria.

2.3 Laboratory analyses

The sampled soils were air-dried, ground and sieved through a 2mm sieve, less than 2mm fractions were used for laboratory analysis. Particle size distribution was determined by the hydrometer method (Agbenin, 1995). Organic carbon was determined by the dichromate wet oxidation method of Walkley and Black (Nelson and Sommers, 1982). The extractable micronutrients: Zn, Cu, Fe and Mn were extracted with 0.1M HCl solution (Osiname *et al.,*

1973) and determined on an atomic absorption spectrophotometer at appropriate wave lengths (Agbenin, 1995

2.4 Data Analysis

The data collected through soil analysis was subjected to analysis of variance (ANOVA) in statistical package for social Science (SPSS) software, version 23 (SPSS, 2015) to assess variations in the soil properties among topographic positions. The mean comparison was done using Duncan multiple range tests ant t-test at $P < 0.05$ significant level. Simple linear correlation analysis was used to show the relationships between micronutrients and other soil properties.

3.0 RESULT AND DISCUSSION

3.1 Physicochemical Properties along a Toposequence in Tula, Gombe State.

Three slope classes were identified and designated as upper-slope (UP), middle slope (MS) and lower slope (LS) based on topographic position. The values of physico-chemical properties of the slope classes are shown in Table 1. The soils were rated using the critical limits recommended by Malgwi (2007). Sand dominated the particle-size fraction of soils. The high total sand content of the soils reflect the granitic origin of the parent materials (Wilson, 2010). The soil texture ranged from sandy loam to sand. Organic carbon (OC) was rated medium been greater than $10gkg^{-1}$.

Table 1: Physicochemical Properties along a Toposequence in Tula, Gombe State.

Locations	Depth	Sand	Silt	Clay	OC	Fe	Mn	Cu	Zn
Upper Slope	0 - 15 cm	82	8	10	14.2	11.5	12.8	4.0	5.7
Upper Slope	15 - 30 cm	83	5	12	13.0	8.3	15.6	4.4	13.9
Middle Slope	0 - 15 cm	84	8	8	10.6	9.6	13.8	3.0	12.0
Middle Slope	15 - 30 cm	83	5	12	7.1	22.4	21.2	4.8	14.1
Lower Slope	0 - 15 cm	85	9	6	13.5	13.2	19.5	3.9	13.4
Lower Slope	15 - 30 cm	86	7	7	7.5	35.0	21.7	3.6	14.6

3.2 Ranking of Mean Soil Properties along Tula Topography

The ranking of mean soil properties along Tula Topography is presented in Table 2

Extractable iron (Fe)

Extractable iron (Fe) value varies within the toposequences. The mean Fe values in the lower slope recorded the highest 24.1 mg/kg, followed by middle slope with 16.0 mg/kg and upper slope with 9.9 mg/kg. All soils along the toposequence were rated high been greater than 4.5 mg/kg. Extractable iron increases with depth as subsoils were significantly ($p < 0.01$) higher than surface soils. High amount of Fe in soils could lead to precipitation and accumulation and upon complex chemical reactions result to the formation of plinthites. This upon alternate wetting and drying could irreversibly form hard indurated material (petrophlintite) which could restrict root penetration and drainage (Ibrahim and Abubakar, 2013).

3.2 Extractable Manganese (Mn)

Extractable Manganese (Mn) value recorded the highest value among the micronutrient in the toposequences. The mean Mn values in the lower slope recorded the highest 20.6 mg/kg, followed by middle slope with 17.5 mg/kg and upper slope with 14.2 mg/kg. All soils along the toposequence were rated high been greater than 5.0 mg/kg. Extractable Mn increases with depth as sub soils were more than surface soils. Extractable Mn values were lower than those reported by Mustapha *et al*., (2010) and Ibrahim and Abubakar (2013) in soils of Gombe. This could be as a result of difference in parent rock as the present study area was under basement complex rock while the previous studies were on sedimentary basin. The high amount of Fe and Mn content of the soils could result to Fe and Mn oxides nodules and concretions found in the subsoils (Odunze and Kureh, 2009). Extractable Mn cannot be a limiting factor to successful crop production in the area. The acidic nature of the soils could be related to the high content of extractable Mn in the soils. The availability of Mn was reported to be very low at soil pH above 7.5 because of the formation of hydroxides and carbonates (Sillanpa, 1982).

3.3 Extractable zinc (Zn)

Extractable zinc (Zn) value varies within the toposequences and values increases down the toposequence. The mean Zn values in the lower slope recorded the highest 14.0 mg/kg, followed by middle slope with 13.1 mg/kg and upper slope with 9.8 mg/kg. All soils along the toposequence were rated high been greater than 2.0 mg/kg. Extractable Zn increases with depth as subsoils were significantly ($p < 0.01$) higher than surface soils. Extractable Zinc values were higher than those reported by Ibrahim and Abubakar (2013) in soils of Yamaltudeba local government of Gombe state. This corroborates Jimoh *et al*. (2015) who also reported high content of extractable Zn in basement complex soils of Zaria.

2.4 Extractable copper (Cu)

Extractable copper (Cu) value varies within the toposequences, values decreases down the toposequence. The mean Cu values in the upper slope recorded the highest 4.2 mg/kg, followed by middle slope with 3.9 mg/kg and lower slope with 3.7 mg/kg. All soils along the toposequence were rated high in Cu been greater than 1.0 mg/kg. Extractable Cu increases with depth as subsoils were more than surface soils. These values were rated high based on micronutrients fertility ratings. Therefore there will be need for supplementary Cu application for sustainable arable crop production. This confirms the report of Odunze and Kureh (2009) who also reported high content of Cu in Zaria soils. This also supports other previous findings (Manoggoel *et al*., 2014).

Table: 2 Ranking of Mean Soil Properties along Tula Topography

Parameters	Sand	Silt	Clay	OC	Fe	Mn	Cu	Zn
Locations	g/kg	g/kg	g/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
US	82.5	6.6	11	13.62	9.90	14.19	4.20	9.79
MS	83.5	6.5	10	8.85	16.01	17.47	3.92	13.06
LS	85.5	8	6.5	10.50	24.08	20.59	3.76	14.03
P-value	0.052	0.696	0.181	0.37	0.48	0.30	0.86	0.52
LOS	NS	NS	NS	NS	NS	NS	NS	NS
SE+	0.6	0.68	1.04	2.90	10.39	3.33	.78	3.49
Depth								
Surface	83.00	8.33	8.00	12.78a	11.46	15.36	3.62	10.38
Subsoils	84.00	5.66	10.33	9.19b	21.87	19.46	4.29	14.21
P-value	0.69	0.15	0.36	0.01	.00	.76	.77	.00
LOS	NS	NS	NS	*	**	NS	NS	***
SE+	1.33	0.74	2.02	1.11	3.89	1.43	.24	1.19

3.3 .Relationship Between some Soil Physicochemical Properties and Micronutrients (Correlation analysis) over the Toposequence in Tula, Gombe.

The Relationship Between some Soil Physicochemical Properties and Micronutrients (Correlation analysis) over the Toposequence in Tula, Gombe is presented in Table 3

The relationship between some of the soil physicochemical properties and micronutrients over the toposequence revealed that silt correlate negatively with clay at (-840*), this implies that, increase in clay content lead to decrease in silt content of the soil

Table 3. Relationship Between some Soil Physicochemical Properties and Micronutrients (Correlation analysis) over the Toposequence in Tula, Gombe.

	Sand	Silt	Clay	OC	Fe	Mn	Cu	Zn
Sand	1							
Silt	.325	1						
Clay	-.787	-.840*	1					
OC	-.398	.445	-.062	1				
Fe	.610	-.160	-.246	-.789	1			
Mn	.632	-.243	-.205	-.688	.793	1		
Cu	-.452	-.708	.722	-.110	.065	.349	1	
Zn	.631	-.408	-.096	-.581	.416	.736	.152	1

*. Correlation is significant at the 0.05 level (2-tailed).

4..0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

. Results obtained shows that the soils were sandy loam to sand in texture and low to medium in organic carbon. The soils were all rated very high in iron (Fe), Manganese (Mn), Copper (Cu) and Zinc (Zn) contents. Extractable Fe and Mn increase down the toposequence while Cu and Zn decreases down the toposequence. All the micronutrients increase with soil depth. The toposequence were all adequate in micronutrient but there are possibilities of micronutrient toxicity which call for caution for sustainable development.

4.2 Recommendations

It is recommended that for successful crop production in the studied area;

1 There is need for the application of organic manure to improve the overall fertility of the soil. Furthermore;

ii Soil testing is recommended before fertilizer application to prevent micronutrient toxicity.

Conflict of Interest

All authors hereby declare that there is no conflict of interest.

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