Original Research Article

Variability of soil extractable micronutrients in the upland and lowland topoposition soils of Gubi village, Bauchi state north eastern Nigeria

Abstract
The aim of this study was to assess the variability of extractable micronutrients in the varying topoposition soils of Gubi village. Four profile pits were dug at each of the designated topopositions making a total of eight profiles. The profiles were dug at the crest, upper slope, middle slope and valley bottom positions of the two toposequences and were named URFGU1, URFGU2, URFGU3 to URFGU4 and URFGL1. URFGL2, URFGL3 to URFGL4 for upland and lowland respectively. The content and profile distribution of extractable micronutrients copper (Cu), Zinc (Zn), manganese (Mn) and Iron (Fe) were extracted using 0.1m HCl solution and determined using atomic absorption spectrophotometer (AAS) at appropriate wavelengths (Ca at 247 nm, Zn at 214 nm, Mn at 279 nm and Fe at 248 nm. Data generated was statistically analyzed using analysis of variance in nested experimental design. The significance of difference between treatments was determined using fishers LSD. Means that were significantly different were separated using the Least Significant Difference (LSD). The result reveals that Copper (Cu), iron (Fe) and manganese (Mn) varied significantly due to location. Iron and manganese were significantly higher in the upland soil (47.35 and 47.50mg/kg respectively) than in the lowland soil (17.67 and 27.38mg/kg respectively). The lowland soil had significantly higher Cu (1.31mg/kg) than the upland soil (0.37mg/kg). Zinc (Zn) did not vary significantly due to location however the lowland soil (0.86mg/kg) had a higher Zn content than the upland soil (0.26mg/kg).

Keywords: Micronutrients, upland, lowland and topopositions

1.0. Introduction

Soil micronutrients are important elements needed in small quantities for plant growth and optimum yields. Soil extractable micronutrients vary in response to time and location. Such variability could be due to landscape and land use, parent material, soil reaction, organic matter content or even pedogenesis etc (Onweremadu and Akamigbo, 2007). Most soils vary in their micronutrient content and deficiency of such nutrients can to severe reduction in yield or even crop failure (Mathayo *et al*, 2016). Hence there is need to study the variability of micronutrients in different topopositions so as to proffer proper soil management practices and to optimize crop yields. Information on the variability of extractable micronutrients in the soils of Gubi village is scanty. Understanding the variability of micronutrients in soils is essential in applying location specific management practices. Therefore, the objective of this study was to assess the variability of extractable micronutrients in the varying topoposition soils of Gubi village. The information gathered can serve for planning soil management practices and to sustain soil micronutrients levels as well as address deficiency if any in the study area.

2.0. Study Area/Site

Gubi lies on latitude 10^{o} 17^{o}N and longitude 10^{o} 15^{o}E in Bauchi state, north eastern Nigeria. The area is 609m above sea level and is of a charnochite, bauchite lithology formed on an older granite suite of Paleozoic age. The soils are mostly shallow to deep (Carter, 1964).

The area falls within the upper fringe of the Northern Guinea Savanna ecological zone (Kaey, 1959)

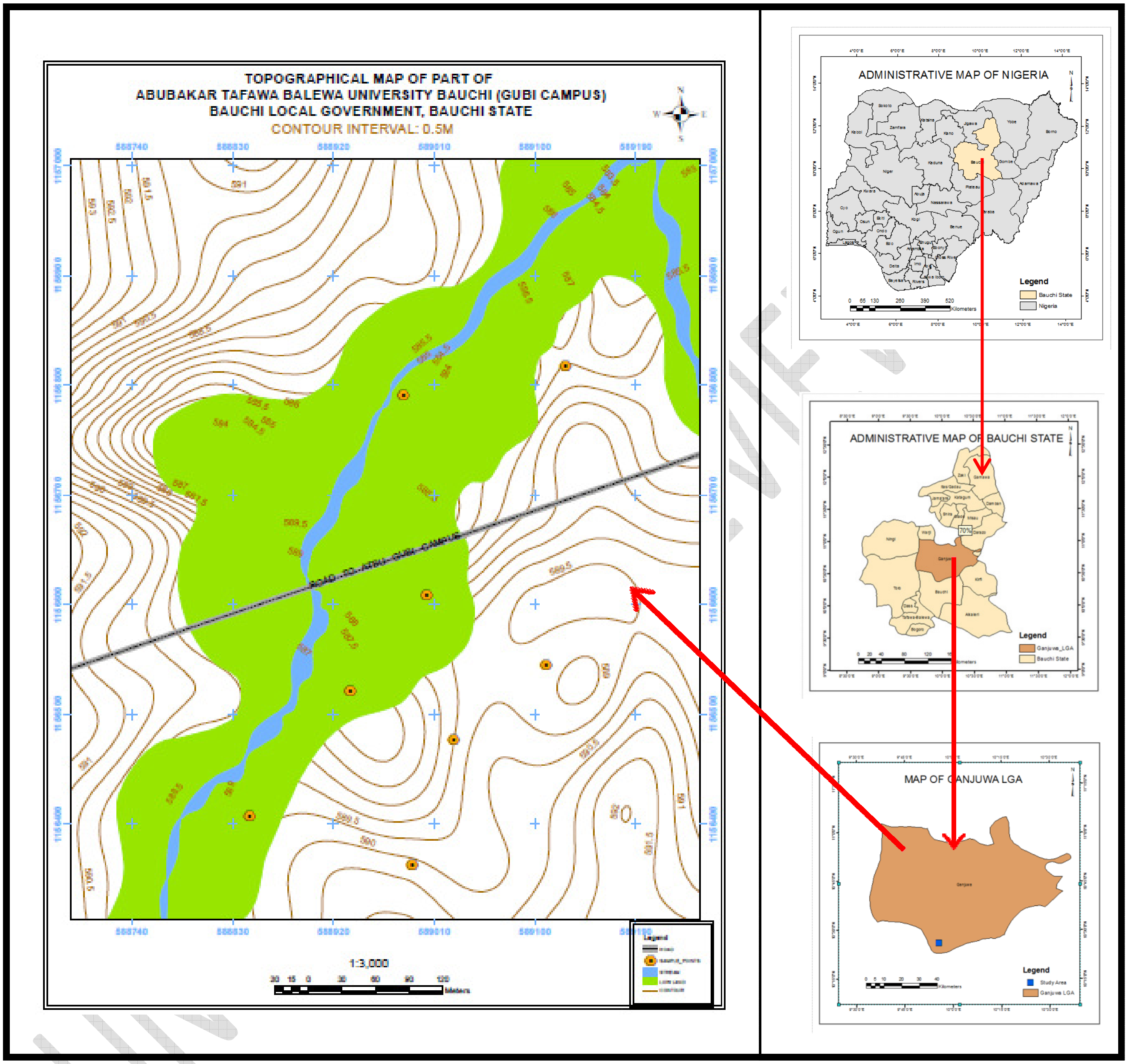

Figure 1: Showing Map of Nigeria, Bauchi State, Study Area and Topographic Map.

2.1. Field Studies

A reconnaissance soil survey was conducted in order to delineate between topoposition soils selected for the study. The soils were selected in a contiguous position in order to allow for comparative studies. Four profile pits were dug at each of the designated topopositions making a total of eight profiles. The profiles were dug at the crest, upper slope, middle slope and valley bottom positions of the two toposequences and were named URFGU1, URFGU2, URFGU3 to URFGU4 and URFGL1. URFGL2, URFGL3 to URFGL4 for upland and lowland respectively. Each profiles pit was 2.0 m long, 1.5 m wide and 2.0 m deep or to a lithic, paralithic or water table contact zone if less than 2.0 m. Profile pits site characteristics were as follows:

Profile pits were described for morphological properties in the field following standard procedures as contained in the Soil Survey Staff (1998). Soil descriptions were done for soil colour (moist and dry moisture condition), presence of mottles (name, notation, abundance, size and contrast) texture, structure (grade, class and type) consistence (dry, moist and wet) presence of cutans (type, frequency and thickness), pores (abundance and size), roots (abundance and size), presence of concretions and nodules, minerals and animal activities as well as horizon boundary (distinctiveness and topography).

2.2. Soil Sampling and Handling

After morphological description of profiles in the field, soil samples were collected from each identified genetic horizon from the bottom upwards, to avoid contamination. The soil samples were placed on polythene bags and labeled appropriately. The soil samples were air dried, ground, using a porcelain pestle and mortar and passed through 2.0 mm sieve. The sieved samples were kept in polythene bags and subjected to laboratory analysis using standard procedures.

Table 1: *Profile Pits Site Characteristics of Study Area*

		Coordinates				
Location	**Topoposition**	**Latitude**	**Longitude**	**Altitude (masl)**	**SP**	**PM**
Upland	URFGU 1	10^{O} 45' 97''E	9^{O} 81' 31''N	585.8	CR	BC
	URFGU 2	10^{O} 46' 07''E	9^{O} 81' 34''N	504.3	US	BC
	URFGU 3	10^{O} 46' 14''E	9^{O} 81' 42''N	587.3	MS	BC
	URFGU 4	10^{O} 43' 80''E	9^{O} 81' 43''N	586.8	VB	BC
Lowland	URFG L1	10^{O} 46' 07''E	9^{O} 81' 18''N	585.8	CR	BC
	URFG L2	10^{O} 46' 06''E	9^{O} 81' 24''N	583.5	US	BC
	URFG L3	10^{O} 46' 19''E	9^{O} 81' 32''N	583.4	MS	BC
	URFG L4	10^{O} 46' 57''E	9^{O} 81' 31''N	582.8	VB	BC

SP = Slope position; **CR** = Crest,
MS = Middle Slope; **VB** = Valley Bottom
PM = Parent Material; **BC** = Basement Complex
Masl = Metres above sea level; **US** = Upper Slope

Extractable micronutrients Analysis

The content and profile distribution of extractable micronutrients copper (Cu), Zinc (Zn), manganese (Mn) and Iron (Fe) were extracted using 0.1m HCl solution and determined on an atomic absorption spectrophotometer (AAS) at appropriate wavelengths (Ca at 247 nm, Zn at 214 nm, Mn at 279 nm and Fe at 248 nm (Jackon 1964).

3.0. Data Analysis

Weighted averages of A and B horizons were calculated for all the topopositions. The data generated was statistically analyzed using analysis of variance in nested experimental design as described by Montgomery (2001). The significance of difference between treatments was determined using fishers LSD. Means that were significantly different were separated using the Least Significant Difference (LSD) as described by Steel and Torrie (1981).

3.1. Results and Discussion

Extractable micronutrients of the upland topopositions are shown in Table 2. Based on the ratings of Esu (1991), Zn was rated “low” in all the horizons of the topopositions of the upland. The highest Zn content was recorded in the AB horizon of URFGU4 (0.75 mg/kg) and the lowest in the BC horizon of the same topoposition. Generally, Zn varied irregularly in all the horizons of the topopositions. Cu content was rated “low” to “medium” in all the horizons of the topopositions in the upland. The highest Cu content was recorded in the Ap horizon of URFGU3 (0.81 mg/kg) and the lowest in the Ap horizon of URFGU2 (25.9 mg/kg). Fe was rated “high” in all the horizons of the topopositions in the upland soils. The highest Fe content was recorded in the Btv horizon of URFGU3 (86.1 mg/kg) and the lowest in the Ap horizon of URFGU2 (25.9 mg/kg). Mn was rated “high” in all the horizons of the upland topopositions. The highest Mn content (83.5 mg/kg) was recorded in the AB horizon of URFGU3 and the lowest in the Ap of URFGU4 (18.2 mg/kg). Generally, the extractable micronutrients were irregularly distributed in all the horizons of the upland topopositions.

Table 2: Extractable Micronutrients in Upland Topoposition Soils

Topoposition	***Depth (cm)***	*Zn*	*Cu (mg/kg)*	*Fe*	*Mn*
URFGU1					
Ap	*0 – 28*	*0.21*	*0.43*	*38.7*	*52.2*
Bt1	*28 – 99*	*0.17*	*0.26*	*42.9*	*66.0*
BC	*99 - 131*	*0.31*	*0.43*	*36.1*	*52.8*
URFGU2					
Ap	*0 – 18*	*0.23*	*0.52*	*25.9*	*40.0*
Bt1	*18 – 56*	*0.27*	*0.36*	*63.8*	*43.2*
BCv	*56 – 121*	*0.18*	*0.21*	*74.3*	*40.9*
URFGU3					
Ap	*0 – 21*	*0.24*	*0.81*	*31.3*	*52.1*
AB	*21 – 51*	*0.18*	*0.36*	*35.3*	*83.5*
Btv	*51 - 99*	*0.34*	*0.55*	*86.1*	*72.2*
BC	*99 – 141*	*0.21*	*0.26*	*40.3*	*34.4*
URFGU4					
Ap	*0 – 16*	*0.36*	*0.53*	*28.2*	*18.2*
AB	*16 – 46*	*0.75*	*0.19*	*57.3*	*60.6*
Bt1	*46 – 96*	*0.20*	*0.17*	*43.8*	*57.2*
BC	*96 – 150*	*0.17*	*0.08*	*62.1*	*48.2*

Extractable micronutrients for the lowland topopositions are presented in Table 3. Zn was rated "low" to "medium" in URFGL1, URFGL2 and URFGL4 and "low" in URFGL3 of the lowland. The highest Zn content was recorded in the Bw horizon of URFGL2 (1.77 mg/kg) and the lowest in the Ap horizon of URFGL4 (0.36 mg/kg). Cu was rated "medium" to "high" in URFGL1, URFGL2 and URFGL4 and "high" in URFGL3. The highest Cu content was recorded in the Ap horizon of URFGL2 (1.95 mg/kg) and the lowest in the Ap horizon of URFGL1 (0.73 mg/kg). Fe was rated "high" in all the horizons of the topopositions in the lowland. The highest Fe content was recorded in the Bw horizon of URFGL2 (25.36 mg/kg) and the lowest in the Ap horizon of the same topoposition (10.11 mg/kg). Mn was rated "high" in all the horizons of the lowland topopositions. The highest Mn content was recorded in the Bw horizon of URFGL4 (38.47 mg/kg) and the lowest in the Ap of URFGL2 (17.40 mg/kg). Generally, Fe and Mn content increased with increase in depth while Zn and Cu were irregularly distributed.

Table 3: *Soil Extractable Micronutrients of Lowland Topoposition Soils*

Topoposition	*Depth (cm)*	*Zn*	*Cu*	*Fe*	*Mn*
			mg/kg		
URFGL1					
Ap	*0 – 43*	*0.38*	*1.25*	*11.26*	*25.62*
Bw1	*43 – 97*	*1.46*	*0.73*	*18.94*	*34.87*
Bw2	*97 – 143*	*1.06*	*0.98*	*23.64*	*29.11*
URFGL2					
Ap	*0 – 30*	*0.56*	*1.95*	*10.77*	*17.40*
Bw	*30 – 146*	*1.77*	*0.87*	*25.36*	*29.33*
URFGL3					
Ap	*0 – 49*	*0.75*	*1.24*	*13.84*	*18.18*
Bw	*49 – 150*	*0.39*	*2.36*	*19.25*	*29.66*
URFGL4					
Ap	*0 – 56*	*0.36*	*0.74*	*18.11*	*29.4*
Bw	*56 – 157*	*1.41*	*1.23*	*22.43*	*38.47*

The result reveals that Copper (Cu), iron (Fe) and manganese (Mn) varied significantly due to location. Iron and manganese were significantly higher in the upland soil (47.35 and 47.50mg/kg respectively) than in the lowland soil (17.67 and 27.38mg/kg respectively). The lowland soil had significantly higher Cu (1.31mg/kg) than the upland soil (0.37mg/kg). Zinc (Zn) did not vary significantly due to location however the lowland soil had a higher Zn content (0.86mg/kg) than the upland soil (0.26mg/kg) The results (Table 4) shows that zinc (Zn), copper (Cu), iron (Fe) and manganese (Mn), varied significantly due to location. Zn and Cu were significantly higher in the lowland while Fe and Mn were significantly higher in the upland soils. Significantly higher Fe and Mn in the upland is as a result of the shallow water table which causes alternate drying and wetting during the dry and wet seasons thereby leading to formation of Fe and Mn concretionary nodules. These Fe and Mn can be reduced, translocated and concentrated in nodular forms (Olaniyan, 2013). This may also lead to the process of laterization and iron accumulation which has been reported to lead to massive assemblage of sesquioxides (Kparmwang *et al*, 2001). The high nature of extractable Fe is consistent with the acidic nature of the soil, as the solubility of Fe increases at low pH (Alemayehu *et al*, (2016) and Habibah *et al* (2014)). Significantly higher Zn and Cu in the lowland soils corresponds with a higher clay content, higher organic matter and carbon as well as nitrogen content in the same location. Zn and Cu might have been translocated and deposited on lowlands. Several workers have reported some factors responsible for availability of micronutrients as parent material, soil reaction, soil texture, soil organic matter, amount of exchangeable bases etc. (Brady and Weil, 2004, Tisdale *et al,* 1995 and Foth and Ellis, 1997). Mathayo *et al*, (2016), reported that soil pH has a direct influence on micronutrients availability by favouring conditions which accelerates oxidation, precipitation and immobilization. Positive correlations were found for Mn and Fe thereby providing favourable conditions for their availability. Solubility of Fe and Mn is known to increase with lowering soil pH (Foth, 1990). Soil pH indicated negative correlation with Zn and Cu. Also high concentrations of Fe and Mn is known to suppress heavy metals like Zn and Cu. Under the same soil pH level, increase in the concentration of Mn was likely to increase Fe availability (Mathayo *et al* 2016).

Table 4: *Influence of Location and Topoposition on Extractable Micronutrients*

Location	*Topoposition/Topoposition*	*Zn (mg/kg)*	*Cu (mg/kg)*	*Fe (mg/kg)*	*Mn (mg/kg)*
L1	*URFGU1*	*0.21*	*0.37*	*39.57*	*56.75*
L1	*URFGU2*	*0.25*	*0.40*	*58.15*	*40.65*
L1	*URFGU3*	*0.30*	*0.47*	*44.68*	*51.28*
L1	*URFGU4*	*0.28*	*0.22*	*47.00*	*41.31*
Mean L1		***0.26[b]***	***0.37[b]***	***47.35[a]***	***47.50[a]***
L2	*URFGL1*	*0.81*	*1.04*	*15.77*	*28.29*
L2	*URFGL2*	*1.17*	*1.41*	*18.07*	*23.37*
L2	*URFGL3*	*0.57*	*1.80*	*16.55*	*23.92*
L2	*URFGL4*	*0.89*	*0.99*	*20.27*	*33.94*
Mean L2		***0.86[a]***	***1.31[a]***	***17.67[b]***	***27.38[b]***
Mean		***0.56***	***0.84***	***32.51***	***37.44***
LS		*NS*	*	***	***
LSD (P<0.05)		*0.57*	*0.58*	*7.61*	*6.07*

LS= Level of significance; LSD= Least Significance Difference; Means with different superscript within a column differ significantly

Agronomic implications of the occurrence of extractable micronutrients in the varying topopositions of Gubi village

Agronomically, the occurrence of the extractable micronutrients in the varying topopositions can be deduced as follows: According to the rating scales of Mathayo *et al*, (2016),Zn was rated 'low' in all the topopositions of the upland soils and 'medium' in all the topopositions of the lowland except in URFGL3 where it was rated 'low'. Cu was rated "medium" in all the topopositions of the upland and "high" in all the topopositions of the lowland except in URFGL4 where it was rated "medium". Fe and Mn were rated "high" in all the topopositions of both the upland and lowland soils. For optimum crop production fertilizers containing Zn should be applied judiciously to all the topopositions of the upland soils and URFGL3 of the lowland while supplemental doses should be applied to URFGL2, URFGL2 and URFGL4. Cu may be applied as supplemental doses to all the upland topopositions since the lowland is not deficient in it. Fe and Mn content are adequate enough in all the topopositions of both the upland and lowland topopositions.

4.0. Conclusion

This study revealed that there was variability in the distribution of extractable micronutrients in the varying topoposition soils of Gubi village. Extractable Fe and Mn increased downslope in both surface and subsurface horizons of both the upland and lowland topopositions while Cu and Zn were irregularly distributed. There was also significant variation in the content of Cu, Fe and Mn due to location with the lowland topopositions having significantly higher values than the upland while Zn did not vary significantly due to location. The observed variability is attributed to translocation and deposition of the micronutrients by moving water, soil textural differences, soil reaction and organic matter content.

Conflict of interest: There is no conflict of interest between the authors.

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