Status of available micronutrients and their correlation with some soil properties in Bade Local Government Area, North Eastern Nigeria

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ABSTRACT

The soils of Bade Local Government Area (LGA) of Yobe State, Nigeria were assessed to determine the micronutrient status and their relationship with pH, electric conductivity and organic carbon. Soil samples were taken from the five major district of the LGA at the depth of 0-20cm using soil sampling auger. The samples were then analyzed using the standard procedures. Results obtained indicated that the mean pH value was 6.45 with 2.97 % coefficient of variability (CV). The mean electric conductivity (EC) showed non saline (0.17dSm^{-1}); while organic carbon (OC) content of the soils was very low (1.03g kg^{-1}). Micronutrients mean concentrations indicated low limit for boron (B) (0.35mg kg^{-1}), moderate values (0.24mg kg^{-1}) for copper (Cu), high concentration of iron (Fe) (5.07mg kg^{-1}) and manganese (Mn) (3.12mg kg^{-1}), while zinc (Zn) was found to low (0.99mg kg^{-1}) in the soils. All the assessed micronutrients showed moderate variability except Zn which is the least. Cu ($r = -0.243$), Fe ($r = -0.370$), Mn ($r = -0.028$) and Zn ($r = -0.196$) showed negative correlation with pH, while only B ($r = 0.043$) and Zn ($r = 0.285$) showed positive correlation with EC. Except for zinc all other micronutrients tested showed positive relationship with OC. The nutrient fertility index of the soils indicated moderate fertility level for B (1.95), Cu (1.80) and Fe (2.00), while Mn (3.00) and Zn (1.50) showed high and low fertility level respectively. The soil management strategies need to put into consideration micronutrients supplement and addition of organic matter.

INTRODUCTION

Micronutrients are such elements that are required in small quantities by plants that are why are called micronutrients. Eight elements are considered essential for plant growth that is in this category; these include boron, chlorine, copper, iron, manganese, molybdenum, nickel and zinc (Das 2015; Brady and Weil 2017).

Micronutrients are equally very important in plant growth as the macronutrients in spite being required in small quantities. Too little or too much of any one micronutrient can stimulate dramatic effects in terms of competitive shift in plant species, stunted growth, low yields, dieback, and even plant death (Brady and Weil 2017).

The importance of micronutrients is beyond plant nutrition, they equally play important roles in human nutrition whose sources are from the grains and vegetables we consume. Manganese, molybdenum, nickel and zinc are very essential micronutrients for human beings, so it is recommended that they should be incorporated into agricultural plans (Akhtar et al. 2019).

The major factors that causes deficiencies of the micronutrients among others include parent materials, pH, organic matter, intensive crop production practices which lead depletion of the nutrients from the soil and the use of highly concentrated fertilizers that often do not supply these micronutrients (Fageria et al. 2002; Udo de Haes et al. 2019). The productivity, stability and sustainability of soils does not only depends on macromutrients, but also deficiencies of the micronutrient may constitute a great restriction (Deshpande and Salunkhe 2013).

Nigerian soils, most especially those of the sahelian region in Nigeria have high declining soil

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fertility. It is indicated that organic carbon, zinc and boron concentrations were below the critical level in the soils of the study area (FAO 2001). Earlier own boron and molybdenum deficiency was reported for soils of semi-arid savanna of Nigeria by Lombin (1985).

The knowledge of micronutrients status and relationship with other soil properties is vital to the management strategies to be adopted for sustainability and improve crop production. In view of that, the research objectives are:

- I. To determine the status of available boron, copper, iron and zinc in the soils of the study area.
- II. To understand the relationship between these micronutrients and some chemical properties in the soils (pH, electric conductivity (EC) and organic carbon (OC))

MATERIALS AND METHODS

The Study Area

The study was conducted between October and December, 2017 at some selected farms in Gashua, GwioKura, Dagona, Usur-Dawayo and Sugum-Tagali. These are the five major Districts in Bade LGA of Yobe State, Nigeria. Bade is located between longitudes 9° 00' and 10° 30' N and latitudes 9° 30' and 10° 30'E. It is situated in the Sahel savanna agro-ecological zone of Nigeria. The climate of the area is characterized by a high temperature and seasonal rainfall. The mean minimum temperature ranged between 10°C to 12°C in December/January, while the mean maximum is about 35-42°C between March and May. The annual average rainfall is about 300-450 mm and is unimodal in distribution and often starts from July and ends in September and the dry season and is from October to May.

Soil sampling and analysis

Four soil samples each were collected from Gashua, GwioKura, Dagona, Usur-Dawayo and Sugum-Tagali at 0-20 depths; making a total of 20 soil samples. The samples were separately packaged in polythene bags for laboratory analysis. The samples were air-dried in the laboratory and passed through 2mm sieve and sieved portion is then used for analyses.

The soil parameters were determined using routine methods as described in Okelebo et al (2002). The pH (in water) was determined potentiometrically using a glass electrode pH meter in a 1:2.5 soil: water suspension, electrical conductivity (EC) was measured using EC meter from saturated paste, while OC was determined by the potassium dichromate wet oxidation method of

Nelson and Sommers (1975). Boron was determined using hot-water method (Estefan et al. 2013). The available Cu, Fe, Mn and Zn in soil samples were extracted with DTPA [0.005 M DTPA+0.01 M CaCl₂+0.1 M triethanolamine, pH 7.3] as described by Lindsay and Norvell (1978) and their concentrations in the DTPA extracts was determined using atomic absorption spectrophotometer.

Data Analyses

The data obtained was analyzed using simple descriptive statistics, analysis of variance and correlation to determine the relationship of the micronutrients to pH, EC and OC contents of the soils using STAR (2013). Micronutrients fertility index (MFI) was calculated using the expression of Parker et al (1951) $MFI = (NL \times 1 + NM \times 2 + NH \times 3) / \text{number of samples}$; Where, NL = number of samples at level of concentration in the soil, NM = number of samples at medium level, and NH = number of samples at high level of nutrient concentration as presented in Singh et al (2018).

RESULTS AND DISCUSSION

The results of the soil properties analyzed were presented in table 1; these include pH, EC, OC, boron, copper, iron, manganese and zinc values across the sampling sites. The pH values range between 6.00 and 7.20 with coefficient of variation (CV) of 2.97%; this indicated that the pH of the soils fall within accept limit for crop production (Brady and Weil 2017). EC values range between 0.09 and 0.20 dSm⁻¹, the soils are non-saline, but indicated moderate variability with a CV of 13.47% within the surveyed areas. Organic carbon (OC) of the soils was generally very low as per the rating of Esu (1991), with mean value of 1.03g kg⁻¹, and showed low variability across the area (Table 1). This conforms to earlier report by Alhassan et al (2018b) for the same area with significant differences across the sampling sites

Boron (B) concentrations in the soils ranged between 0.26 and 0.50mg g⁻¹ and 20.13% CV. The moderate variability in the boron concentrations of the soils, of which about 80% fall within the low limit (<0.5mg g⁻¹) and 5% as medium concentration as per the rating in table 4. This is an indication of inadequacy of boron level in the soils for good crop growth. Fertilization program for these soils may require inclusion of boron.

Copper (Cu) concentration in the soils was between 0.13 and 0.36mg g⁻¹. 80% of Cu concentrations were in the moderate level while, the remaining 20% was rated low (Table 4). The soils Cu level is not limiting as such fertilization that will include copper is not necessary. The Cu concentration varied moderately among the sample areas.

Table 1. Soil nutrients status of the study areas (Bade LGA)

Location	pH	EC	OC	B	Cu	Fe	Mn	Zn
Dagona	6.00	0.13	1.10	0.26	0.28	6.16	2.35	1.10
Dagona	6.20	0.11	1.13	0.31	0.18	6.71	3.86	0.95
Dagona	6.20	0.14	1.12	0.50	0.23	4.77	3.61	1.13
Dagona	6.40	0.11	1.11	0.27	0.23	6.21	3.01	0.85
Gashua	7.20	0.15	0.93	0.39	0.19	4.09	2.48	0.82
Gashua	7.30	0.16	1.04	0.45	0.36	5.15	3.42	0.86
Gashua	7.30	0.22	1.12	0.31	0.21	3.46	3.36	0.98
Gashua	7.80	0.17	0.75	0.34	0.13	5.50	3.12	1.10
Gwio-Kura	6.00	0.09	0.96	0.36	0.33	6.66	3.81	0.93
Gwio-Kura	6.20	0.09	0.96	0.38	0.20	3.20	3.64	1.07
Gwio-Kura	6.30	0.09	1.05	0.32	0.23	6.28	2.38	0.82
Gwio-Kura	6.50	0.09	1.04	0.37	0.34	4.09	3.61	0.98
Sugum-Tagali	6.20	0.19	0.78	0.31	0.24	5.19	2.44	1.04
Sugum-Tagali	6.20	0.26	1.10	0.42	0.22	5.85	3.17	1.09
Sugum-Tagali	6.50	0.22	1.00	0.26	0.34	4.37	2.87	1.09
Sugum-Tagali	6.50	0.22	1.09	0.42	0.34	5.84	2.34	1.12
Usur-Dawayo	6.50	0.20	1.06	0.30	0.21	5.19	3.41	1.08
Usur-Dawayo	6.60	0.25	1.14	0.35	0.17	4.08	3.51	0.90
Usur-Dawayo	6.70	0.25	1.13	0.32	0.21	5.06	2.54	1.01
Usur-Dawayo	6.80	0.23	1.08	0.39	0.24	3.60	3.42	0.93
Mean	6.57	0.17	1.03	0.35	0.24	5.07	3.12	0.99
CV (%)	2.97	13.47	9.84	20.13	26.63	20.64	17.15	10.25

Iron (Fe) was found to be adequate, which varied between 3.20 and 6.71mg g⁻¹. The data in Table 1 showed that 85% of the values across the areas are rated high, while 15% rated moderate (Table 4). Similarly Iron fertilization for these soils is not necessary.

Manganese (Mn) content in the soils range between 2.35 and 3.86 mg g⁻¹ and is rated 100% high considering the ratings in Table 4 (high is >2.0 mg g⁻¹). The soil will require close monitoring to avoid Mn toxicity.

The high concentrations of iron and manganese recorded could be attributed to the slightly acidic nature of the soils and was in conformity of the findings of Mulima et al (2015) for the soils of similar environment in Yobe State, Nigeria.

Zinc (Zn) concentrations in the soils was low to moderate, with 50% below the limiting value

(<1.0 mg g⁻¹) and 50% within the medium value (1.0 -1.5 mg g⁻¹) as presented in Table 1. The soils may require site specific fertilization including zinc.

Many other researchers that recorded similar findings to ours' include Dogo et al (2017) who reported low levels of zinc and boron; and medium values for zinc (1mg g⁻¹) and high values for copper (2mg g⁻¹); low to medium for Mn and low values for Fe for soils of a similar agro ecology in Nigeria. While Alhassan et al (2018a) reported results which conform to this finding; where B was rated low and in sufficient (0.33mgkg⁻¹) while, Zn (0.98mgkg⁻¹) was in the medium class and marginal.

Shehu et al (2015) also observed similar trend in the Sudan savanna of Nigeria where zinc and copper had moderate values, while manganese and iron showed high concentrations in the soils of

Table 2. Means separation of the soil properties by areas of sampling

Location	pH	EC	OC	B	Cu	Fe	Mn	Zn
Dagona	6.20c	0.123c	1.11	0.34	0.23	5.96	3.21	1.01
Gashua	7.40a	0.175b	0.96	0.37	0.22	4.55	3.09	0.94
Gwio-Kura	6.25c	0.090c	1.00	0.36	0.28	5.06	3.36	0.95
Sugum-Tagali	6.35c	0.223a	0.99	0.35	0.29	5.31	2.70	1.08
Usur-Dawayo	6.65b	0.233a	1.10	0.34	0.21	4.48	3.22	0.98
SE	0.138*	0.016*	0.072ns	0.05ns	0.046ns	0.74ns	0.378ns	0.072ns

Table 3. Correlation coefficients of relationship between micronutrient and soil chemical properties

Soil property	B	Cu	Fe	Mn	Zn
pH	0.118	-0.243	-0.370	-0.028	-0.196
EC	0.043	-0.141	-0.280	-0.208	0.285
OC	0.066	0.118	0.037	0.173	-0.113

sudan savanna zone of Nigeria. Bichi and Solomon also reported high values for manganese and iron, while low values were reported for zinc and copper in Kano a sudano-sahelian region of Nigeria.

Several other workers such as Ibrahim et al (2011), Ephraim (2012) and Mustapha et al (2011) have reported results which are in agreements with our findings.

Table 4. Rating of soil properties concentrations

Soil property	Low	Medium	High
B	<0.5	0.5 – 1.0	>1.0
Cu	<0.2	0.2 – 0.5	>0.5
Fe	<2.0	2.1 – 4.0	>4.0
Mn	<1.0	1.0 – 2.0	>2.0
Zn	<1.0	1.0 – 1.5	>1.5

Table 5. Soil Micronutrients Fertility Index of the soils of Bade LGA

Nutrient	Fertility Index
Boron	1.95
Copper	1.80
Iron	2.00
Manganese	3.00
Zinc	1.50

Relationship of the micronutrients with some chemical properties

The correlation study presented in table 3 showed that Copper, iron, manganese and zinc all showed inverse relationship with pH ($r = -0.243$, -0.370 , -0.028 and -0.196 respectively), while boron ($r = 0.118$) showed positive correlation with pH. This indicated that with the exception of boron which likely increase with an increase in pH, the rest will decrease with an increase in pH or vice versa. Similarly Cu, Fe and Mn correlations with pH was reported to be negative by Vijayakumar et al (2011).

The relationship with EC showed that B ($r = 0.043$) and Zn ($r = 0.285$) had a positive correlation

Table 6. The fertility index ratings

Nutrient Index Range	Remark
< 1.67	Low
1.67 – 2.33	Moderate
>2.33	High

while, Cu ($r = -0.141$), Fe ($r = -0.280$) and Mn ($r = -0.208$) depicted negative relationship with EC.

B ($r = 0.066$), Cu ($r = 0.118$), Fe ($r = 0.037$) and Mn ($r = 0.173$) correlated positively with OC, while zinc ($r = -0.113$) shows negative correlation with the organic carbon (Table 3).

Soil fertility index

The fertility indices of the soils of Bade could be classified as moderate (1.67-2.33) as per boron, copper and iron concentrations, high (>2.33) in manganese (3.00) concentration and low in fertility index as per Zinc (1.50) concentration based on the ratings in Table 6. Therefore the soils are deficient in zinc which may require fertilization, while other micronutrient are within sufficiency limits, but will require close monitoring to prevent inadequacy and toxicity.

CONCLUSIONS

The soils of Bade Local Government Area are moderate in pH, non-saline, low in organic carbon and deficient in zinc and boron while, copper, iron and manganese are in adequate quantities. Integrated fertilizer management practices are highly recommended to sustainably maintain the soils for good crop production.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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