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Full Length Research Paper

Status and distribution of extractable micronutrients in Haplustults in Yamaltu-Deba Local Government Area, Gombe state, Nigeria

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A study was conducted to determine the status and distribution of extractable Zn, Cu, Fe and Mn in Haplustults in Yamaltu-Deba Local Government Area (LGA) of Gombe State, Nigeria. Composite soil samples representative of the soils in the LGA were collected from 0 - 15 and 15 - 30 cm depths of five locations (Hinna, Kanti, Jangargari, Gidan Waya and Dadin Kowa) and analyzed. Results indicate that the soils were dominantly sandy loam, very strongly to moderately acidic (pH = 4.7 - 5.9) and low in CEC (mean = 7.21 cmolkg^{-1}), exchangeable bases (Means for Ca = 3.34, Mg = 0.71, K = 0.21, Na = 0.10 cmolkg^{-1}) and organic carbon (mean = 7.27 g kg^{-1}). Extractable Zn, Cu, Fe and Mn (in mgkg^{-1}) were 0.48 - 0.75 (mean = 0.58), 0.18 - 0.26 (mean = 0.21), 18.40 - 21.91 (mean = 19.96), and 30. 54 - 38.58 (mean = 33.00), respectively. The micronutrients were neither significantly (P = 0.05) influenced by the depths nor locations. The Fe and Mn contents were above the critical limits for crop production in all the locations. Copper was low in soils from Hinna and Jangargari and will consequently benefit from its application. Zinc was, however, generally low and its application in all the locations are recommended for successful crop production in the area.

Key words: Haplustults, micronutrients, distribution.

INTRODUCTION

Micronutrients refer to a number of metals and their ions which are mostly of high density (usually > 5.0 mgm^{-3}) and belong largely to the group of "transition elements' of the periodic table. They are usually of relatively low abundance in soils but play key roles in the growth and development of crop plants, hence, essential for plant growth.

In Nigeria, micronutrient deficiencies were quiet rare, owing in part to the extensive system of agriculture practiced that permitted the recuperation of soils; hence, replenishing its macro- and micro-nutrients that were hitherto lost. The increasing human and animal population in Nigeria in general and in Gombe State in particular, and the country's drive to attain food security, has necessitated the abandonment of the traditional extensive agricultural system, to a more scientific intensive one. This, coupled with the use of new high yielding crop varieties which are nutrient demanding, and the realization of the concept of balanced nutrition by farmers have unraveled micronutrient deficiencies in some Nigeria Savanna soils (Mustapha and Loks, 2005).

The drive towards self sufficiency in food production through the adoption of more scientific intensive agricultural systems has necessitated the evaluation of the nutrient status of soils; most especially the micronutrients which had hitherto been neglected (Mustapha, 2003). This study was conducted to evaluate the status and distribution of zinc, copper, iron and manganese in the Haplustults of Yamaltu-Deba LGA in Gombe State, Nigeria.

MATERIALS AND METHODS

The study area

The study was conducted in Yamaltu-Deba LGA, Gombe State, Nigeria, situated about 609.5 m above the sea level. It is in the

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Table 1. Distribution of particle-size fractions, pH and Organic Carbon in some soils in Yamaltu-Deba LGA, Gombe State.

	Sand (%)	Silt (%)	Clay (%)	Texture*(%)	pH (in water)	Org. C. (gkg^{-1})
Location						
Hinna	40.9	27.4	31.7	CL	5.18	10.18
Kanti	68.2	13.4	18.3	SL	4.77	7.11
Jangargari	59.6	23.6	16.2	SL	5.93	7.11
Gidan Waya	59.6	22.1	18.3	SL	5.10	5.23
Dadin Kowa	56.9	18.8	24.3	SCL	5.75	6.55
Mean	57.0	21.1	21.9		5.5	7.27
LSD (P=0.5)	21.6	11.47	13.52		0.89	2.84
Depth (cm)						
0 – 15	57.3	22.6	20.1	SL	5.27	7.81
15 - 30	57.0	17.5	23.5	SCL	5.42	6.73
Mean	57.2	21.0	21.8		5.35	7.27
SE $\pm$	3.88	2.06	2.43		0.15	0.89

Texture: CL = Clay loam, SL = Sandy loam, SCL = Sandy clay loam.

northern guinea savanna agro-ecological zone of Nigeria (BSADP, 1982). Its geomorphology comprises of greatly undulating plains and pediments.

The climate is characterized by high temperatures and seasonal rainfall. The mean temperature ranges from 30 - 32°C. The rainfall pattern is unimodal, ranging from 700 - 1250 mm and is characterized by distinct dry (October - May) and rainy (June - September) seasons.

Soil sampling and handling

Six representative composite soil samples each were collected from two depths (0 - 15 and 15 – 30 cm) from five locations (Hinna, Kanti, Jangargari, Gidan waya, and Dadin kowa) in Yamaltu-Deba LGA; making a total of 60 samples. Each soil sample was a composite of five sub-samples. The collected soil samples were stored in properly labeled polythene bags and taken to the laboratory for analyses. In the laboratory, each sample was separately dried in air, ground using a porcelain pestle and mortar and passed through a 2 mm sieve. The sieved samples were used for all laboratory analyses.

Laboratory analyses

The processed soil samples were analyzed for some physico-chemical properties including the micronutrient (Zn, Cu, Fe and Mn) under investigation following procedures described by Page et al. (1982). Particle size distribution was determined by the hydrometer method after dispersing in sodium hexametaphosphate solution (Bouyoucos, 1951). The soil pH was determined in 1:1 soil/water suspension using a glass electrode pH meter while organic carbon in the soil was determined by the wet combustion method of Walkley and Black (1934). Cation exchange capacity was estimated using the NH_4OAc saturation (pH 7) method, while the leachate was used to determine the exchangeable bases. 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.

For the purpose of micronutrient fertility ratings, the limits given by Esu (1991) were employed. For Zn, values < 0.8, 0.81 – 2.0 and >2.0 $mgkg^{-1}$ were respectively rated 'low", 'medium' and 'high' while for Cu, the respective fertility category rating limits were < 0.2, 0.21 – 2.0 and > 2.0 $mgkg^{-1}$. Iron was regarded as 'low' if < 2.5, 'medium' if 2.51 – 5.0 and 'high' if > 5.0 $mgkg^{-1}$. Manganese was low if the values were < 1.0, 'medium' if 1.1 - 5.0, and 'high' if > 5.0 $mgkg^{-1}$.

Data analysis

Data obtained were subjected to statistical analysis using the analysis of variance (Harry and Steven, 1995). Means that were significantly different were separated using the least significant difference (LSD).

RESULTS AND DISCUSSION

The data on the physico–chemical properties of the soils studied are presented in Tables 1 and 2. Table 1 shows the particle-size distribution of the soils in the study area. The sand, silt and clay fractions ranged, respectively, from 40.9 - 68.2 (mean = 57.0), 13.4 - 27.4 (mean = 21.1), and 18.3 - 31.7(mean = 21.9)%, giving the soils a generally sandy loam to clay loam texture. The fractions varied significantly (P < 0.05) between locations but not with depths.

The soils were generally acidic with soil pH varying widely from 4.77 (very strongly acid) to 5.93 (moderately acid) between the locations. Organic carbon content was generally low (mean = 7.27 gkg^{-1}) except at Hinna (10.18 gkg^{-1}) where it was medium (Esu, 1991). Gidan Waya (5.23 gkg^{-1}) and Dadin Kowa (6.55) recorded the lowest soil organic carbon (matter) contents. Depths considered did not significantly (P = 0.05) influence the organic

Table 2. Distribution of exchangeable bases and CEC (in cmol (+) kg^{-1}) in some soils in Yamaltu–Deba Local Government Area Gombe State, Nigeria.

	Ca^{2+}	Mg^{2+}	K^+	Na^+	CEC
Location					
Hinna	3.17	0.79	0.22	0.07	6.74
Kanti	3.96	0.81	0.23	0.08	7.64
Jangargari	3.68	0.68	0.21	0.16	7.69
Gidan Waya	2.79	0.64	0.17	0.07	6.19
Dadin Kowa	3.08	0.62	0.22	0.12	7.79
Mean	3.34	0.71	0.21	0.10	7.21
LSD(P=0.05)	NS*	NS	NS	NS	NS
Depth (cm)					
0 – 15	3.71	0.64	0.19	0.08	7.54
15 - 30	2.95	0.77	0.23	0.13	6.88
LSD (P= 0.05)	NS	NS	0.04	NS	NS

*NS = Not significant.

Table 3. Distribution of some extractable micronutrients (in $mgkg^{-1}$) in soils of Yamaltu – Deba Local Government Area, Gombe State, Nigeria.

	Zn	Cu	Fe	Mn
Location				
Hinna	0.51	0.18	19.74	31.34
Kanti	0.45	0.21	21.91	38.58
Jangargari	0.75	0.19	20.42	30.54
Gidan Waya	0.48	0.21	19.31	31.62
Dadin Kowa	0.69	0.26	18.40	32.62
Mean	0.58	0.21	19.96	33.00
SE $\pm$	0.15	0.06	3.51	4.51
LSD(p=0.05)	NS	NS	NS	NS
Depth (cm)				
0 – 15	0.54	0.18	22.12	33.62
15 - 30	0.61	0.24	17.80	32.38
SE $\pm$	0.09	0.04	2.22	2.85
LSD(P=0.05)	NS	NS	NS	NS

carbon content.

The exchangeable bases were generally low in the soils (Table 2). Their distribution was neither influenced by the locations nor by the depths considered; except for K^+ that was significantly ($P < 0.05$) higher in the lower 15 – 30 cm (0.23 cmol(+)kg^{-1}) than the upper 0 to 15 cm (0.19 cmol(+)kg^{-1}). The CEC was generally low (<10 cmol (+) kg^{-1}) probably indicative of the presence and dominance of 1:1 kaolinitic and/or Fe ad Al oxide clays.

Zinc status

Table 3 shows that Zn content in the soils ranged from 0.48 to 0.78 (mean = 0.58) $mgkg^{-1}$. This, in line with the ratings provided by Esu (1991), is “low”. The values recorded for there soils fall below the 1.2 – 4. 0 $mgkg^{-1}$ obtained by Kparmwang and Malgwi (1997) for the soils in the Northern guinea Savanna of Nigeria, 0.81 to 1.34 (mean = 1.13) $mgkg^{-1}$ for Ustults in Galambi District in

Bauchi State, Nigeria (Mustapha and Singh, 2003) and 1.1 to 6.9 $mgkg^{-1}$ obtained for volcanic ash soils elsewhere in Tanzania (Kamasho and Singh, 1982). It is pertinent to note that the Zn values obtained in this study fall below the critical 0.90 $mgkg^{-1}$ given by Lombin (1983). It, therefore, follows that for successful and sustainable crop production in all the locations studied, Zn application will prove beneficial.

Copper status

With Cu ranging from 0.81 to 0.26 (mean = 0.21) $mgkg^{-1}$ (Table 3), it is rated, according to Esu (1991), as generally “medium”. It is noted, however, that soils from the locations: Hinna (0.18 $mgkg^{-1}$) and Jangargari (0.19 $mgCukg^{-1}$) fall below the critical 0.2 $mgkg^{-1}$ suggested by Esu (1991) and Lindsay and Norvell (1978) for optimal crop growth. These soils, falling in the “low” fertility category may hence, benefit from Cu application.

It is noteworthy (Table 3) that soils in the upper 0 -15 cm contained Cu (0.18 $mgkg^{-1}$) below the critical value of 0. 20 $mgkg^{-1}$ while those at the lower 15 – 30 cm depth contained higher Cu contents (0.24 $mgkg^{-1}$). While advocating for Cu application, light turning of the soils could also prove beneficial for crop production in the study area.

Iron status

Table 3 shows that Fe in the soils studied ranged from 18.40 to 21.91 (mean = 19.96) $mgkg^{-1}$. These values are much higher that the critical 2.5 $mgkg^{-1}$ reported by Esu (1991), but similar to the 12.40 - 45.1 $mgkg^{-1}$ reported by Mustapha and Singh (2003) for Ustults in similar agro-ecology in Nigeria. It is, therefore, unlikely that Fe deficiency is experienced in these soils. This is true especially when viewed against the report (Chen and Barak, 1982; Sakal et al., 1984; Mengel and Geurtzen, 1986) that Fe deficiency is unlikely in acid soils; as Fe is known to be soluble under relatively acidic and reducing conditions (Chesworth, 1991).

The presence of high concentrations of Fe in soils could lead to its precipitation and accumulations and upon complex chemical reactions, lead to the formation of soft unindurated plinthite (laterite). This, upon alternate wetting and drying, could irreversibly form hard indurated material called petroplinthite (Ironstone) which would restrict rooting depth and drainage, amongst others.

Manganese status

Available Mn in the area studied ranged from 30.54 to 38.58 (mean = 33.00) $mgkg^{-1}$ (Table 3). It is rated “high” in its status (Esu, 1991). This implies that the soils contain Mn above the critical available range of 3 to 5 $mgkg^{-1}$ reported by Lindsay and Norvell (1978) and 1 - 5 $mgkg^{-1}$ reported by Esu (1991). The values obtained for these soils are above those obtained for some Ustults in Bauchi, Nigeria (7.89 – 12.00; mean = 9.10 $mgkg^{-1}$) but averages about the 19.0 – 69 .3 $mgkg^{-1}$ reported by Kparmwang (1996) in similar Nigerian soils. The high content of available Mn in the soils may be related to the acidic nature of the soils. It has been reported (Sillanpaa, 1982) that above soil pH of 7.5, the availability of Mn is very low because of the formation of hydroxides and carbonates.

Concluding remarks

The results of the present study have indicated that soils in the study area ranged from moderately to extremely acidic (pH range = 4.7 – 5.9; mean = 5.4), low in CEC (mean = 7.2 cmol kg^{-1}) and exchangeable bases. The available Fe and Mn in the soils studied were found to be above the critical ranges suggested by Esu (1991). This means that deficiency symptoms of these plant nutrients on crops grown on these soils is unlikely. For Cu (except at Hinna and Jangargari that were low and will thus benefit from Cu application), the soils contained sufficient quantities of the plant nutrients and may not be supplemented. Zinc in the soils was low indicating that crops grown on these soils will benefit from its application.

REFERENCES

Bouyoucos CA (1951). A re-calibration of the hydrometer for making mechanical analysis of soils. Agron. J., 31: 510-513.

BSADP (1982). Bauchi State Agricultural Project. Zonal and Development Area Statistics, Bauchi, Nigeria. pp. 90-100.

Chen Y, Barak P (1982). Iron nutrition of plants in calcareous soils. Adv. Agron., 35: 217 -240.

Chesworth W (1991). Geochemistry of nutrients. In: J. J. Mortredt, L. M., Shuman and R. M. Welch (eds). Micronutrients in Agriculture, 2nd Edition Soil Science Society of America Inc., Madison, Wisconsin, USA. Pp. 427 -476.

Esu IE (1991). Detailed Soil Survey of NIHORT farm at Bunkure, Kano Sate, Nigeria. Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria. p. 32.

Harry F, Steven CA (1995). Statistics: Concepts and Applications. Cambridge University Press, Great Britain. p. 853.

Kamasho JA, Singh BR (1982). Available copper and zinc status of some Tanzanian volcanic ash soils: A case study. Pedologie., 32: 209-224.

Kparmwang T (1996). Inherent fertility status of upland and fadama soils in Bauchi State, Nigeria. Noma. 12: 1-7.

Kparmwang T, Malgwi WB (1997). Some available micronutrients in profiles of Ultisols and Entisols developed from sandstone in north-western Nigeria. In: B.R. Singh (Ed.). Management of Marginal Lands in Nigeria. Proceedings of the 23rd Annual Conference of Soil Science Society of Nigeria, UDU, Sokoto, Nigeria. pp. 245-255.

Lindsay WL, Norvell WA (1978). Development of DTPA soil test for zinc, iron, manganese and copper. Soil Sci. Soc. Am. J., 42: 421-428.

Lombin G (1983). Evaluating the micronutrient fertility of Nigeria’s semi-arid savanna soils. 2. Zinc. Soil Sci., 136: 42-47.

Mengel K, Geurtzen G (1986). Iron chlorosis on calcareous soils. Alkaline nutritional conditions as the cause of chlorosis. J. Plant Nutr.

9: 161-173.
Mustapha S (2003). Fertility status and productivity constraints of the basement complex-derived Ustults in Bauchi State,Nigeria. J. Agric. Technol., 11: 11-19.
Mustapha, S. and Singh, B.R. (2003). Available zinc, copper, iron and Manganese status of the basement – complex rock–derived Ultisol in Bauchi State, Nigeria: A case study. Nig. J. Soil Res., 4: 35-40.
Mustapha S, Loks NA (2005). Distribution of available zinc, copper, iron and manganese in the fadama soils from two distinct agroecological zones in Bauchi State, Nigeria. J. Environ. Sci., 9(2): 22-28.
Osiname OA, Schults BT, Corey RB (1973). Soil tests for available copper and zinc in soils of Western Nigeria. J. Sci. food Agric., 24: 1341-1349.
Page ALP, Miller RH, Keeny DR (1982). Methods of Soil Analysis. Agron. ASA, Madison, Wisconsin, USA. 9: 2.
Sakal R, Singh BP, Singh AP (1984). Determination of threshold value of iron in soils and plants for the response of rice and lentil to iron application in calcareous soils. Plants and Soils., 82: 141-148.
Sillanpaa M (1982). Micronutrients and the nutrient status of soils. A global study FAO Soils Bulleting, 48, Rome, Italy.
Walkley A, Black CA (1934).Acid extractable Zn in soil in relation to the occurrence of Zn deficiency symptoms of corn: A method of analysis. Soil Sci. Soc. Am. Proceedings. 12: 143-148.