Asian Journal of Agriculture and Food Science (ISSN: 2321 - 1571)
Volume 01– Issue 05, December 2013

Extractable Micronutrients Status in Relation to other Soil Properties in Jangargari, Yamaltu-Deba Local Government Area, Gombe State

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ABSTRACT— ***A study was conducted to evaluate extractable micronutrient (Fe, Cu, Zn and Mn) status and their relationship with soil properties in Yamaltu-Deba Local Government Area of Gombe State, Nigeria. Fifty five (55) composite soil samples were collected at 0 to 30 cm depth and analyzed for physico-chemical properties and status of extractable micronutrients. Results indicate that the soils were dominantly Clay loam, pH were slightly to moderately acidic (pH = 5.9 - 6.7) low in organic carbon (mean = 7.6 gkg^{-1}) and high in CEC (mean = 13 cmolkg^{-1}). Extractable Fe, Cu, Zn and Mn (in mgkg^{-1}) were 13.1 to 19.7 (mean = 16.3), 0.19 to 0.33 (mean = 0.26), 0.49 to 0.93 (mean = 0.72), and 18.9 to 29.8 (mean = 27.4), respectively. Further, Fe showed positive correlation with clay and CEC but negative correlation with pH, silt and Oc. Mn also showed positive correlation with silt but negative correlation with pH, clay, CEC and Oc. Cu showed positive correlation with pH, silt, CEC and Oc and negative correlation with clay. Zn also followed the same trend as that of Cu with pH, silt, CEC and Oc and negative correlation with clay. The extractable Fe and Mn contents were above the critical limits for crop production in all the locations. Copper and Zinc were low in some places and their application are recommended for successful crop production in the area.***

Keywords— DTPA-extractable, pH, micronutriments, soil properties

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1. INTRODUCTION

Micronutrients are needful elements for normal growth of plants, that are needed at little amount Fageria [1]. If these elements are not available sufficiently, plants will suffer from physiological stresses cause by inefficiency of several enzymatic systems and other related metabolic functions Baybordi [2]. Soil fertility is one of the important factor controlling yields of the crops. Introduction of high yielding varieties in Nigeria Agriculture forced the farmers to use high dose of NPK along with micronutrients fertilizers. This caused declined in the level of some micronutrients in the soil at which productivity of crops cannot be sustained. The deficiencies of micronutrients have become major restrictions to productivity, stability and sustainability of soils. Nutrients strength and their relationship with soil properties affect the soil health.

In recent years large hectares of Arable land in Nigeria have been reported to be deficient in micronutrients and many of these deficiencies were brought about by the continuous use of inorganic fertilizers particularly nitrogen, phosphorus, and potassium by farmers, limited use of organic manures as well as non recycling of crop residues are some of the other factors contributing towards rapids exhaustion of micronutrient in soils. [3,4]. 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 [5]. However, understanding micronutrient levels in these soils is imperative not only for improvement of our soils data bank, but also for agricultural planning development and identifying areas where micronutrient fertilizers will be useful for higher crop yield and economic return.

2. MATERIALS AND METHODS

2.1 The Study Area

The study was conducted in Jangargari located in Yamaltu-Deba Local Government Area of Gombe State, Nigeria. It is situated within Latitudes 10^0 13’ North of the Equator and Longitudes 11^0 23’ East of Greenwich meridian and about 609.5 m above the sea level. It is in the northern guinea savanna agro-ecological zone of Nigeria [6]. 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 and it experiences a relative humidity of 17 – 90 percent. The average rainfall of the area is 800 – 900 mm and is characterized by distinct dry (October - May) and rainy (June - September) seasons.

2.2 Soil Sampling and Handling

Fifty five (55) composites samples were randomly collected at 0 to 30 cm depth using soil auger to avoid any contamination of the soils. 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.

2.3 Laboratory Analyses

The processed soil samples were analyzed for some physicochemical properties including the micronutrient (Zn, Cu, Fe and Mn) under investigation following procedures described by [7]. Particle size distribution was determined by the hydrometer method after dispersing in sodium hexametaphosphate solution [8]. 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 [9]. Cation exchange capacity was estimated using the NH4OAc saturation (pH 7) method. The extractable micronutrients: Zn, Cu, Fe and Mn were extracted by DPTA according to [10] and the metals in the extract were determined using an atomic absorption Spectrophotometer. The relationship between various soil properties and micronutrient content was established using simple correlation [11].

3. RESULT AND DISCUSSION

3.1 Physico-chemical Properties

The data on the physico–chemical properties of the soils studied are presented in Tables 1. The Table shows the particle-size distribution of the soils in the study area. The sand, silt and clay fractions ranged, respectively, from 40 - 46 (mean = 42), 26 - 37 (mean = 30), and 23 – 31 (mean = 28) %, giving the soils a generally Clay loam. The soil reaction ranged from pH 5.9 – 6.7 (mean=6.2) indicating slightly to moderately acidic reaction in all the study area. Organic carbon content was generally low and varied from 5.2 – 9.1 g kg^{-1} (mean = 7.6 g kg^{-1}). The very low OC content of these soils may be attributed to the poor vegetation and high rate of organic matter decomposition under hyper-thermic temperature regime which leads to extremely high oxidizing conditions [12]. The results of the present investigation are in close proximity with the findings of [13]. The cation exchange capacity ranged from 9 to 17 cmol (+) kg^{-1} (mean 13 cmol (+) kg^{-1}). The relatively higher values of CEC indicate that some 2:1 clay mineral, probably Mortmorillonite and/or Illite, were present in the clay fractions.

Table 1*:* Range and average values of physico-chemical properties of soils of Jangargari

Parameter	Range	Mean
Sand (%)	19 – 33	24.5
Silt (%)	26 – 36	31.3
Clay (%)	38 – 48	44.1
pH	6.2 – 7.6	6.90
OC (gkg^{-1})	10.7 – 13.9	12.39
CEC [cmol (+) kg^{-1}]	15.4 – 27.1	22.4

Cation Exchange Capacity (CEC) is expressed as cent moles of positive charge per kilogram (cmol kg^{-1})

3.2 Iron (Fe) Status

Table 2 shows that Fe content ranged from 13.1 to 19.7 mg/ kg^{-1} with a mean of 16.3 mg/ kg^{-1}. Similar values were obtained by [14]. The estimated data indicated that all soils are non deficient in extractable iron. Even through the soil contained iron above the critical 2.5 mg kg^{-1}given by [15]. The content indicates that with value above critical limits for crop, iron deficiency is unlikely for any crop grown on these soils. The high values are apparently due to the nature of part rock, namely, highly ferruginised sandstone, this is especially so when viewed against the backdrop of reports [16] that Fe deficiency is very unlikely in acid soils; as it known to be soluble under relatively acid and reducing conditions [17]. Values reported in this study are lower than the ones reported by [18] for soils in Gombe State (18.40 – 21.9mg/ kg^{-1}). However the presence of Fe in high concentrations in soils could lead to its precipitation and accumulation and upon complex chemical reactions lead to the formation of plinthites (late rite). This upon alternate wetting and drying could irreversibly form hard indurated material (petrophlintite or ironstone) which could restrict root penetration and drainage.

The r-value between extractable Fe and soil pH was - 0.437. It showed that there was negative non significant correlation between Fe and soil pH; silt and organic carbon contents with r-value were - 0.327 and - 0.370 respectively. Similar negative non significant correlation between Fe and soil pH were reported by [19] elsewhere in Shirpur Tahasil, India. Their availability in the area is not dependent on any significant extent on any of these soil properties. These results are in agreement with findings of [20] while analyzing available micronutrient in profiles of ultisols and entisols developed from sandstone in north western Nigeria.

3.3 Copper (Cu) Status

Table 2 shows that Cu in the soils ranged from 0.19 to 0.33 mg/ kg $^{-1}$ with a mean of 0.26 mg/ kg $^{-1}$, based on the [15], micronutrients fertility ratings it falls in the “low” to ‘medium’ categories, Table 3 and could therefore require supplementary Cu applications for sustainable arable crop production. This also agrees with findings of [21] when they studied soils of Akko Local Government area of Gombe State in the same agro – ecological zone. These results were also similar to those obtained by [18] when they studied soils of Yamaltu – Deba Local Government Area of Gombe State (mean = 0.21mg kg $^{-1}$).

The data given in Table 4 shows that Cu was positively correlated with soil pH, CEC and organic carbon with (r) value 0.169, 0.236 and 0.313 respectively. These results were supported by [3, 4, 22 and 23] who also reported positive significant correlation between Cu and soil pH, CEC and organic carbon. The correlation value (r) between Cu and Silt was 0.519. It showed that silt was positive none significantly correlated with Cu. Similar results were obtained by [24] who obtained positive correlation between Cu and silt contents. The correlation value (r) between Cu and Clay was -0.525. It shows that Cu had negative significant correlation with Clay. This indicates that as clay increases, availability of Cu decreases. This result disagrees with the earlier findings of [4] who reported positive significant correlation between Cu and Clay content.

3.4 Zinc (Zn) Status

The DTPA extractable Zinc in soils ranged from 0.49 to 0.93 mg/ kg $^{-1}$ with a mean value of 0.72mg/ kg $^{-1}$. Based on the critical values of [15] (Table 3) the Zn contents fall in the category of ‘low’, Suggesting that some parts of the study area are deficient in extractable Zn and would require Zn fertilization for a better arable crop production. Similar results were observed by [25].

The statistical analysis Table 4 shows positive correlation between Zn and soil pH, CEC and Oc with r-value 0.116, 0.390 and 0.054. These results corroborate the earlier reports [3, 26, 23, 4 and 27]. The correlation r value between Zn and silt was 0.474. It shows that Zn had positive none significantly correlated with silt. Similar results were obtained by [24] who reported positive correlation between Zn and silt content.

3.5 Manganese (Mn) Status

Manganese (Mn) in the soils (Table 2) ranged from 18.9 to 29.8 mg/ kg $^{-1}$ (mean = 27.4 mg/ kg $^{-1}$), according to the rating of [15] it is rated ‘High’ in all the locations Table 3. This implies that soils content of Mn is above the critical available range of 3 to 5 mg/ kg $^{-1}$ reported by 5 and 1 – 5mg/ kg $^{-1}$ reported by [15]. These figures suggest that Mn content of the soils is high and cannot be a limiting factor to successful crop production in the area. The high content of available Mn in the soils may be related to the acidic nature of the soils. [28] reported that availability of Mn is very low when the soil pH is above 7.5; this is because of the formation of hydroxides and carbonates.

The data given in Table 4 shows that Mn was negatively correlated with soil pH, Clay, CEC and organic carbon with (r) value -0.556, -0.364, -0.179 and -0.267 respectively. This indicates that as soil pH, Clay, CEC and organic carbon increases, availability of Mn decreases. This result corroborates the reports of [29, 30]. The correlation value (r) between Mn and silt was - 0.065. The results indicates negative non significant. This result was dissimilar to the findings of [24] who reported positive correlation between Mn and silt content.

Table 2*:* Range and average values of physico-chemical properties of soils of Jangargari

Parameter (mgkg^{-1})	Range	Mean
Fe	10.31 –20.17	14.48
Cu	4.04 – 8.43	6.19
Zn	2.62 – 7.02	4.65
Mn	10.88 – 26.74	17.59

Table 3: Critical limits for interpreting levels of soil nutrients

Rating Parameter	Low	Medium	High
OC (g kg $^{-1}$)	<10	10 –15	> 15
CEC [cmol (+) kg $^{-1}$]	<6	6 – 12	> 12
Fe (mg kg $^{-1}$)	<4.5	4.5 – 10.0	> 10
Cu (mg kg $^{-1}$)	<0.2	0.2 – 1.0	> 1.0
Zn (mg kg $^{-1}$)	<0.8	0.8 – 2.0	> 2.0
Mn (mg kg $^{-1}$)	<5	5 – 10	> 10

Adapted from [5, 15]

Table 4: Correlation matrix between micronutrients and some soil properties

Parameter	Soil properties				
	pH	Silt	Clay	CEC	OC
Fe	- 0.437	- 0.327	0.470	0.053	- 0.370
Cu	0.169*	0.519	- 0.525**	0.236**	0.313**
Zn	0.116**	0.474	- 0.542*	0.390**	0.054**
Mn	- 0.556**	0.069	- 0.364*	- 0.179**	- 0.266**

**1% significant
* 5% significant

4. CONCLUSION

Results from the present study indicated that the soils were generally clay loam in texture, slightly acidic to moderately acidic (5.9-6.7) and low in organic carbon with high CEC. Zn was generally low while Cu contents ranged from low to medium in the study area respectively. Equally worthy of note is that the soils contained Fe and Mn above the critical limits for crop production. However, this may pose a potential environmental problems, upon complex chemical reaction, which result in the formation of plinthites and petroplinthites leading to hard pan formation; restricting rooting depth and causing infiltration and drainage problems in the soil. The results also indicated that soil properties pH, CEC, Clay and OC as the main characteristics playing major role in controlling the availability of micronutrients. These factors could be manipulated in order to combat any present or future deficiencies of micronutrients in these soils. It is recommended that for successful crop production in the area studied; application of Organic matter to improve the overall fertility of the soil and to reduce the possible development of plinthitic/ petroplinthic layers. Moreover, crops grown in the area will benefit from Zn and Cu application.

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