

ASSESSMENT OF PHYSICO-CHEMICAL PROPERTIES IN RELATION TO ZINC CONTENT OF SOME SOILS AT NEAZDP IN YOBE STATE NIGERIA

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ABSTRACT

Twenty four soil samples were collected at the depth of 0-15 cm from different locations of the North Eastern Arid Zone Development Programme (NEAZDP) area in the Yobe State. Samples were analysed for texture, pH, EC, Exchangeable Cations, Organic Carbon, Total Nitrogen, Available Phosphorus and available Zinc. The result obtained showed that the texture ranged from sandy loam to clay loam. The pH ranged from 5.2 to 7.1, EC 0.07 to 0.20 MScm⁻¹, ECEC 1.81 to 5.78 Mg/100g Soil, organic carbon 0.12 to 2.00%, total Nitrogen 0.01 to 0.08%, available phosphorus 2.00 to 11.00 Mg/kg soil, with a mean values of 6.37, 0.105 MScm⁻¹ 2.687 Mg/100g soil, 0.757%, 0.023%, 6,812 Mg/kg soil respectably. Most of the soils were sandy, slightly acidic to slightly alkaline, free of salinity, low in organic carbon and medium in P. The 0.1N HCl extractable Zinc was medium (4.5-10Mg/kg soil in most of the samples.

KEYWORDS: Zinc, NEAZDP, Physico-Chemical

INTRODUCTION

Soil productivity depends largely on pool of exchangeable bases which Zinc is included. The aim of this research is to investigate the status of this important micronutrient in some soils in Yobe state. Zinc is one of the plant nutrients recognized universally by soil scientists. Zn is classified as a micronutrient due to its physiological role and requirement in small quantities by plants. It is one of the plant nutrients which received considerable attention in the research programmed during the last four decades due to its importance in plant growth. Zinc is a moderately reactive metal. It does not occur free in nature but is found mainly as calamine, (ZnCO₃) and Zinc blende, (ZnS).

Plant grown on Zinc deficient soils show mottling of leaves as an early visual symptom of Zinc deficiency. Advanced stages are complete chlorosis of parts of affected leaves and eventual necrosis. In severe Zinc deficiency there may be absence of flowers and failure of reproductive phase (Shukla and Raj 1987 and Shukla and Raj 1988).

Pecan rosette, the yellow of walnut trees, the mottle leaf of citrus, the little leaf of stone fruits, cotton and grapes and the bronzing of the leaves of long trees, are all ascribed to Zinc deficiencies.(Henry,1978). The above details bring out the importance of Zinc in the nutrition of plants, as well as in animals. Directly or indirectly, most of the Zinc requirement of plants and animals has to be met from the soil.

From what has been discussed above, the essentiality of Zinc in plant nutrition is obvious. However, in order to make a judicious recommendation on Zinc fertilization, information on distribution of available Zinc in relation to soil properties is essential for each area. The physico-chemical properties of the soil to greater extent affect the content, distribution and availability of soil Zinc.

MATERIALS AND METHODS

Soil sampling

Twenty four (24) composite soil samples were collected at the depth of 0-15 cm from the development units of NEAZDP area in Yobe State and stored in a clean polythene bags for the analysis. Portion of soil samples were taken out before crushing for general analysis. The remaining was crushed by using wooden motor and pestle and was passed through a 2mm sieve.

Laboratory Analysis

Particle size analysis

Particle size distribution was determined by hydrometer method as described by Bonyoucos 1962. The textural class determined using the USDA textural triangle. The Soil pH was measured in water (1:2.5). The Electrical Conductivity (EC) was determined in 1:2.5 soil water suspension using EC meter. Organic Carbon was determined using the dichromate oxidation method of Walkley-Black (1965) while the total nitrogen contents of the soil samples were determined using the micro-kjeldahl method. Available phosphorus was extracted by Bray-I method as described by Bray and Kurtz (1945). The exchangeable cations were determined by leaching the soil with 1N ammonium acetate. The exchangeable bases (Na, K, Ca and Mg) were extracted with 1N NH₄Ac and Na and K in the extract were determined by the use of Flame Photometer while Mg and Ca were determined by titrating with 0.01N EDTA.

Zinc Determination with 0.1N HCl

Ten gram of each soil sample were weighed into a plastic bottle, 50ml of 0.1N HCl were added into the plastic bottle. The soil and solution suspension was shaken for two hours on the shaker and filtered through Whatman filter paper number 1. The extract was used to determine Zinc content using Perkin Atomic Adsorption Spectrophotometer (AAS) model 290 B.

RESULTS AND DISCUSSION

a) Physical properties

Soil Texture

The texture of the soil sample ranged from sand to clay loam as shown in Table 1. The percentage of sand, silt and clay ranged from 30.2 to 91.5%, 2.0 to 43.0%, 5.7 to 33.7% with mean values of 79.32%, 10.70% and 9.98% respectively. The clay content was the lowest among the soil separates and sand content was the highest.

Most of the soil samples were sandy in nature, Sandy soils were found around Dapchi, Turban gida, Ardori, Gumsa 1-3, Mugurum 1-2, Bulungwal to Bulunguwa 2, Dumbule 1 and 2, finally Lawandi.

Clay loam soil were found around Garin Gambo area.

b) Chemical Properties

Soil Reaction

The soil pH ranged from 5.2 to 7.1 with mean value of 6.35 (Table 2). The soil pH of sandy soils ranged from 6.0-7.0 with a mean value of 6.35. On the basis of classification of soil pH given by Danahue et al. (1977), the soil samples were generally slightly acidic to slightly alkaline. Majority of the soils fall within the neutral pH range. This pH range is the optimum for proper growth of most crop plants.

Electrical conductivity (EC)

The electrical conductivity of the soil samples ranged from 0.05 MScm⁻¹ to 0.20 MScm⁻¹ with a mean value of 0.11 MScm⁻¹ (Table 2).

Organic carbon

In sandy soils, organic carbon content ranged from 0.12 to 1.32% with a mean value of 0.605%. In clayey soil the range was from 1.14 to 3.19% with a mean value of 1.974%. The result showed that organic carbon content was low in sandy soils and moderate to high in clayey soil.

Generally, the organic carbon content of the soil samples is low. Therefore, these soils would also be low in productivity.

Effective Cation Exchange Capacity (ECEC)

The ECEC ranged from 1.81 to 6.14 me/100g soil with a mean value of 2.70 Me/100g soil (Table 2).

The exchangeable Ca ranged from 0.4 to 3.4 with a mean value of 1.03 Me/100g soil. Exchangeable Mg ranged from 0.1 to 1.9 with a mean value of 0.54 Me/100g soil. The exchangeable K ranged from 0.13 to 0.65 with value of 0.50 Me/100g soil. The exchangeable Na ranged from 0.11-0.25 with a mean value of 0.14 Me/100g soil. Soils are generally very low in exchange capacity. Thus, the nutrient reserve ability is low. This may be attributed to the fact that most of the soils are sandy in nature.

Available phosphorus

Available phosphorus content ranged from 2.0 to 11.0 with a mean value of 4.98 mg/kg soil (Table 2). Available phosphorus was very low in some soil samples like Gumsa 2 and 3 Dunori 2, moderate in about 90% of the soil samples (ranging from 4.0-10 mg/kg soil). Available

phosphorus content was significantly positively correlated with organic carbon content ($r = 0.455^*$). Soils with high organic carbon content had high content of available phosphorus. This is due to the fact that phosphorus in the organic form could be mineralized to the available inorganic form.

Total nitrogen content (TN)

Total nitrogen content ranged from 0.01 to 0.08% with a mean value of 0.02% (Table 2) Total nitrogen was highly significantly positively correlated with organic carbon content ($r=0.788^{**}$). The low level total N. may be associated with the low organic matter content of the soil which result in low mineralization. Similar results were obtained in some fadama elsewhere (Singh et. al., 1999)

II DISTRIBUTION OF 0.1 N HCl EXTRACTABLE ZINC IN THE SOIL SAMPLES

The data for 0.1N HCl extractable Zinc are presented in Table 3.

The 0.1N HCl extractable Zinc ranged from 4.3 to 12.5 with a mean value of 8.55 mg/kg soil. In sandy soils, the range was from 4.3 to 8.1 with a mean value of 8.09 mg/kg soil. The corresponding values for clayey soils were 10.5-13.6 with a mean value of 12.52 mg/kg soil. This showed that clayey soils contained more 0.1N HCl extractable Zinc than sandy soils.

Soils from Ardori, Balle 1, Balle 2 and Balle 3, Mungurum 1 and 2, Bulunguwa 1 and 2, Dabule 1 and 2, all fall within the range of high Zinc content. Based on study of critical limit of micronutrient in soils and plants by Shukla and Singh (1974), 4.5 ppm could be taken as the critical limit of 0.1N HCl extractable Zinc. The 0.1N HCl extractable Zinc contents below 4.5 ppm were considered as low, while Zinc contents from 4.5 to 10 ppm were taken as medium. Any value above 10 ppm was considered as high. Apparently Zinc content of these soils was higher than those reported, by Shukla et al. (1987) and Shukla and Kwari (1989) for some Chad Basin soils. This difference could be attributed to the relative less use of NEAZDP soils for agricultural purposes.

Relationship of 0.1N HCl extractable Zn with some Physico-chemical Properties of the soils

The correlation coefficient values 'r' are presented in Table 4. The 0.1N HCl extractable Zn was significantly positively related to pH ($r=0.297$), organic carbon ($r=0.497^{***}$), available P ($r=0.453^{**}$), exchangeable Ca ($r=0.695^{**}$), ECEC ($r=0.605^{**}$), and clay ($r=0.563^{**}$).

Shukla and Kwari (1989) reported significant positive correlation of 0.1N HCl extractable Zn with clay in surface and with O.C and pH in subsurface soil samples. The results showed that clayey soils are expected to retain more 0.1N HCl extractable Zn. Shukla et al. (1987) and Shukla and Kwari (1989) while working with Chad Basin soils also reported higher Zn content in clayey soils.

Table 1 Some Physical properties of some Soil Samples from NEAZDP AREA IN Yobe State

Location	Sand	Silt (%)	Clay	Textural class
S Dapchi	81.0	9.3	9.7	LS
Turbangida	87.0	7.3	5.7	LS
Ardori	81.0	11.3	7.7	LS
Garbowa	85.0	7.3	7.7	LS
Gumsa .1	87.0	7.3	5.7	LS
Gumsa 2	79.0	11,3	9.7	SL
Gumsa 3	67.0	23.3	9.7	SL
Dunori	77.0	23.3	9.7	SL
Ngayawa	79.0	11.3	9.7	SL
Belle 1	61.0	25.3	13.7	L
Belle 2	81.0	9.3	9.7	LS
Belle 3	81.0	9.3	9.7	LS
Dumburi 1	73.0	15.3	11.7	SL
Dumburi 2	77.0	11.3	11.7	SL
Mugurom 1	69.0	15.3	15.7	SL
Mugurom 2	83.0	7.3	9.7	SL
Garin Gambo	41.0	25.3	33.7	CL
Garin Maje	83.0	9.3	7.7	LS
Jaba	81.0	9.3	9.7	LS
Bulunguwa 1	90.2	2.0	7.8	S
Bulunguwa 2	90.2	2.0	7.8	S
Dabule 1	90.2	2.0	7.8	S
Dabule 2	90.2	2.0	7.8	S
Lawandi	90.2	2.0	7.8	S
Mean (X)	79.33	10.70	9.98	

TABLE 2: SOME CHEMICAL PROPERTIES OF SOME CHEMICAL PROPERTIES FROM THE SOIL SAMPLES FROM NEAZDP AREA IN YOBE STATE.

Soil Sample No	SoilpH water 1:2.5	EC MS cm-1	Exchangeable Cation (me/100gsoil)					ECEC	Organic carbon (%)	Total N (%)	Available P mg/kg soil
			Ca	Mg	K	Na	H ²⁺ A1 ³⁺				
1	6.20	0.12	0.60	0.90	0.41	0.12	0.50	2.53	0.78	0.03	9.00
2	6.90	0.09	0.50	1.00	0.33	0.16	0.70	2.69	0.48	0.03	11.00
3	6.30	0.10	0.80	0.40	0.33	0.13	0.40	2.06	0.50	0.03	6.00
4	6.50	0.09	0.80	0.10	0.45	0.14	0.40	1.89	0.72	0.03	5.00
5	6.60	0.16	0.60	0.30	0.38	0.12	0.50	1.90	1.12	0.02	9.00
6	5.20	0.15	0.80	0.20	0.28	0.14	0.70	2.12	1.08	0.02	2.50
7	6.10	0.09	0.80	0.30	0.31	0.15	0.50	2.06	0.60	0.02	2.00
8	6.20	0.07	0.70	0.40	0.24	0.12	0.60	2.06	0.78	0.02	4.00
9	5.90	0.07	0.40	0.20	0.47	0.14	0.60	1.81	0.82	0.04	4.00
10	5.40	0.10	11.40	0.40	0.23	0.19	1.10	3.32	1.14	0.04	5.00
11	6.20	0.08	0.70	0.40	0.37	0.13	0.50	2.10	0.66	0.04	5.00
12	6.70	0.12	0.70	0.70	0.55	0.13	0.45	2.53	0.12	0.02	8.00
13	6.60	0.17	0.90	0.20	0.65	0.19	0.60	2.54	1.04	0.02	5.00
14	5.30	0.07	0.90	1.30	0.21	0.16	0.90	3.47	0.88	0.01	2.00
15	6.60	0.20	2.60	1.90	0.58	0.15	0.55	5.78	31.32	0.05	6.00
16	7.10	0.10	1.00	1.50	0.37	0.11	0.40	3.38	0.46	0.01	6.00
17	5.60	0.20	3.40	1.10	0.54	0.25	0.85	6.14	2.00	0.08	8.00
18	6.30	0.07	0.70	0.40	0.26	0.12	0.35	1.83	0.60	0.01	6.00
19	6.70	0.10	0.90	0.60	0.37	0.14	0.40	2.41	0.62	0.01	2.00
20	6.60	0.08	1.20	0.40	0.19	0.12	0.40	2.31	0.46	0.01	2.00
21	7.00	0.11	1.30	0.30	0.24	0.14	0.45	2.43	0.50	0.01	2.50
22	7.00	0.08	1.10	0.30	0.13	0.11	1.40	3.04	0.42	0.01	7.00
23.	6.40	0.07	1.00	0.40	0.13	0.14	0.55	2.22	0.44	0.01	4.00
24.	6.80	0.05	1.00	0.3	0.21	0.12	0.50	2.13	0.44	0.01	2.50
MEAN (X)	6.35	0.11	1.03	0.54	0.50	0.14	0.60	2.70	0.75	0.02	4.90

TABLE 3: DISTRIBUTION OF 0.1N HCl AND EXTRACTABLE ZINC IN SOIL SAMPLES FROM NEAZDP AREA IN YOBE STATE

LOCATION	0.1N HCl EXTRACTABLE ZINC (mg/kg soil)
1	8.8
2	5.5
3	6.2
4	5.7
5	6.6
6	5.1
7	5.5
8	5.2
9	4.3
10	10.5
11	9.0
12	7.5
13	8.3
14	6.5
15	11.2
16	8.5
17	12.5
18	9.1
19	8.3
20	7.5
21	8.0
22	8.1
23	7.7
24	7.6
Mean X	7.63

TABLE 4: Values 'r' (Correlation Coefficients) showing Relationship of 0.1N HCl and DTPA extractable Zinc with some important Physico-Chemical Properties of the Soil Samples

0.1N HCl EXTRACTABLE ZINC	'r'
0.1N HCl Extractable Vs pH	0.29*
0.1N HCl Extractable Vs Avail, P	0.453**
0.1N HCl Extractable Vs O.C	0.497**
0.1N HCl Extractable Vs Clay	0.563**
0.1N HCl Extractable Vs Ex Ca	0.695**
0.1N HCl Extractable Vs CEC	0.605**

(r values equal or exceeding 0.2404, 0.2774 0.3685 also significant at 10, 5 and 1% levels respectively).

* Significant at 5%

** Highly significant at 1%

CONCLUSION

The objective of the project was to study Zinc distribution in relation to other physico-chemical properties of some soils of North Eastern Arid Zone Development Project (NEAZDP) area in the Yobe State of Nigeria. Twenty four composite soil samples were collected and analysed for physico-chemical properties and 0.1N HCl extractable Zinc using recommended laboratory procedures. The results obtained are summarised as follows: - The sand, silt and clay contents have mean values of 78.38, 11.33 and 10.46 percent, respectively. Soil texture ranged from sand to clay loam. Most of the soils studied were sandy in texture. The pH has a mean value of 6.35. Most of the soils fall within the range of slightly acidic to slightly alkaline range which is optimum for crop growth. E.C. has a mean value of 0.11 MScm⁻¹. Soils were presently free from salinity

hazard. Organic carbon content has a mean of 0.75%. In general, the organic carbon content of the soils was low. Exchangeable Ca, Mg, K and Na have mean values of 1.03, 0.54, 0.50 and 0.14 me/100g soil respectively. ECEC has a mean value of 2.70 me/100g soil. In general, the nutrients reserve capacity of the soil is low due to the low exchange capacity. Available P has mean value of 6.8 mg/kg soil, Available and was significantly positively correlated with organic carbon content (r=0.455**). The 0.1N HCl extractable Zinc ranged from 4.3 to 14.5 with a mean value of 8.55 mg/kg soil. Based on study of critical limits of micronutrients in soils and plants by Shukla and Singh (1979), most of the soil samples were medium in Zinc content (4.5-10 ppm).

Using the critical limit of 4.5 ppm for 0.1N extractable Zn and 1 ppm for DTPA extractable Zinc, presently most of the soil samples have been found to fall in the medium Zinc status since most of these soils have not been cultivated intensively. Further, there are a lot of changes in surface layer of soil each year due to wind erosion and aeolian deposit. Apparently, soils of NEAZDP area presently do not suffer from the

deficiency of available Zn. However, keeping in view that sandy nature of most of the soil with increasing crop intensity, these soils are expected to be exhausted soon. The application of Zn containing compounds e.g. ZnSO₄ will result in yield increase. The use of N.P.K, is essential to increase yield, because the soils contain low level of these essential nutrients.

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