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Inherent Fertility Status of Alfisols, Incepfisols and Entisols in the Gubi Soil Series, Bauchi, Bauchi State, Nigeria

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Abstract: The fertility status of Alfisols, Incepptisols and Entisols in the Gubi soil series were evaluated. The soils were generally slightly acid to moderately acid and the pH was significantly ($p<0.01$) higher in the lower horizons than in the surface horizons. Exchangeable acidity was low in the Alfisols and Inceptisols and high in one profile of the Entisols with a significant ($p<0.01$) difference between the profile contents. Exchangeable bases were high to medium in the Alfisols, while in the Inceptisols calcium content was high; magnesium medium, potassium and sodium were low. In the Entisols, calcium content was high with medium magnesium and sodium contents and low potassium. Magnesium and sodium were significantly ($p<0.01$ and $p<0.05$) different between profiles. The sodium, content of the three soil orders was also significantly ($p<0.01$) different, Entisols had significantly higher values than the other soils. Cation Exchange Capacity was medium to high in Alfisols and medium in the Inceptisols and Entisols while base saturation was medium in the Alfisols and Inceptisols and high (statistically $p<0.01$ different) in the Entisols. Organic carbon, total nitrogen and available phosphorus were generally low across the soil orders. Intensive cultivation with increase use of organic matter and careful application of inorganic fertilizers is suggested for optimum crop production.

Key words: Fertility, alfisols, inceptisols, entisols

INTRODUCTION

The World population particular that of developing and under developed countries is growing at an alarming rate. The need to feed this ever-increasing population has become very compelling. In the arid and semi arid regions of Africa, the population growth rate is far ahead of the food production. Food production in this part of the World remains largely on an extensive scale where lands are cultivated for sometime with little inputs and allowed to fallow for years before again cultivating. The cost of farm input especially inorganic fertilizer has also been on the increase coupled with soil degradation due to rapid erosion and loss of organic matter from the soil.

Soil chemical properties are a result of both the factors of soil formation and the various processes of soil change. During weathering, the soil minerals slowly disintegrate and decompose. In the process, individual ions are released from the minerals and are dissolved in soil water. In addition, the dissolved nutrients may also be lost in drainage water. Clearly, therefore, the rate and type of weathering act as an important control on the nutrient content of the soil. The nutrient supply of the soil is generally constrained by the character of the mineral particles and hence, by the parent materials of the soil and by the organic properties of the soil.The inherent nutrient content of soils in the savanna is known to be low (Kparmwang and Esu, 2000; Mustapha, 2000)

In order to meet the food needs of the ever-expanding population, there is the urgent need to increase yield from increase production. The soils of these areas are however, said to be low in native fertility. To enable efficient and proper use of inorganic fertilizers to increase food production and shift significantly from extensive cultivation to intensive cultivation, there is a compelling need to know the inherent fertility status of the soils. The need to maximize the use of land resources and inorganic fertilizer application has necessitated this study.

MATERIALS AND METHODS

Site information: The study area is located at Gubi, about 12 km north west of Bauchi town. The geology of the area is mainly undifferentiated basement complex with granite as the predominant parent material. The site is characterized by gently sloping plains running from the base of the inselbergs to the major watercourses. The climate makes for two seasons-dry and wet seasons lasting from October to March and April to September respectively. The mean monthly temperatures vary between 22.2°C in December and 29.7°C in April/May. The area lies within the northern guinea savanna ecological

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zone of Nigeria with stony and moderately deep soils. The soil moisture regime is ustic moisture regime with isohyperthermic temperature regime. The vegetation consists of grassland interspersed with trees and shrubs including *Combretum* sp., *Parkia clappertomiana* and *Butyrospermum parkii.* Land use includes the cultivation of millet, sorghum, cowpea and grazing.

Soil survey: Six profile pits, two each representing Alfisols, Inceptisols and Entisols were dug and the morphological properties of each soil horizon in each pit was described following standard procedures as described by Soil Survey Manual (Soil Survey Staff, 1999). Soil samples were then collected from the different horizons and subjected to laboratory analyses.

Laboratory analysis: Laboratory analysis was conducted using standard laboratory procedures as described by Agbenin (1995). Soil pH was determined in water at 1:2.5 soil: solution ratio using a glass electrode pH meter. Particle size distribution was determined using the hydrometer method. Organic carbon was determined by the wet oxidation method (Allison, 1965) while total nitrogen was determined by the modified micro-Kjeldal method as described by Bremner (1965). Available phosphorus was determined by the Bray 1 method while the exchangeable bases were determined by atomic absorption spectrophotometer and flame photometry for calcium and magnesium and potassium and sodium, respectively. CEC was determined by the 1N NH_4 saturation method while exchangeable acidity was by titration.

Data analysis: Data collected were subjected to statistical analysis in a nested design using the Minitab soft ware F-test. The Least Significant Difference (LSD) as described by Steel and Torrie (1981) was used to separate means that were statistically significant.

RESULTS AND DISCUSSION

The chemical properties of the soils are presented in Table 1-3 while a summary of the statistical analysis is presented in Table 4. Table 5 indicates the critical limits for interpreting levels of analytical parameters.

Table 1: Chemical properties alfisols at Gubi

Horizon	Depth (cm)	pH (H_2O)	Exchangeable bases: Ca	Mg	K	Na	Exchange acidity	CEC	BS (%)	C	N	P
			(cmol (+) kg^{-1})							(g kg^{-1})		(mg kg^{-1})
Profile 01T4												
A	0-13	5.60	7.10	1.90	0.16	0.14	0.16	10.6	88	3.39	1.4	6.04
Bk1-A	13-35	5.93	6.40	0.48	0.09	0.12	0.70	10.2	74	2.79	1.7	3.51
Btk2	35-57	6.08	6.20	0.03	0.16	0.10	0.42	15.1	63	2.99	1.7	3.80
Btk3	57-92	5.71	7.80	3.66	0.15	0.09	0.52	18.4	64	2.39	1.4	7.45
Btk4	92-130	6.12	10.00	3.66	0.16	0.11	0.38	17.0	82	1.00	1.3	2.53
	Mean	5.78	7.53	2.14	0.15	0.12	0.33	13.2	80	2.76	1.4	5.23
Profile 01T3												
AP	0-14	6.01	4.60	1.53	0.08	0.08	0.36	8.9	71	3.19	1.8	2.51
Bck1-A	14-31	5.62	7.50	0.85	0.07	0.12	1.76	8.4	100	3.99	1.4	13.91
Bctk2	31-63	5.91	7.30	1.33	0.08	0.14	0.96	21.2	42	3.19	1.3	3.12
Bctk3	63-118	6.77	10.70	1.47	0.10	0.14	1.60	21.0	57	3.19	1.4	3.35
	Mean	6.15	6.87	1.43	0.09	0.11	0.09	11.5	65	3.26	1.6	3.76

Table 2: Chemical properties of inceptisols at Gubi

Horizon	Depth (cm)	pH (H_2O)	Exchangeable bases: Ca	Mg	K	Na	Exchange acidity	CEC	BS (%)	C	N	P
			(cmol (+) kg^{-1})							(g kg^{-1})		(mg kg^{-1})
Profile 02T1/03T1												
AP	0-26	5.64	4.44	0.38	0.06	0.13	0.24	8.60	58	6.38	1.4	5.64
Ck1-B	26-57	6.09	8.20	1.53	0.07	0.12	0.32	12.00	83	4.40	1.4	3.37
Cck2	57-115	6.09	7.00	0.53	0.08	0.13	0.34	11.30	69	2.00	1.1	2.57
	Mean	5.87	5.93	0.63	0.07	0.13	0.29	7.57	66	4.61	1.3	4.27
Profile 00T2/01T2												
A	0-24	6.47	10.40	0.98	0.09	0.13	0.36	12.40	94	1.60	1.8	3.31
AB	24-34	5.27	4.20	0.37	0.06	0.07	0.36	7.60	62	8.78	1.3	2.78
CB	34-60	6.12	4.20	1.17	0.20	0.08	0.20	10.40	54	4.99	1.4	5.43
	Mean	6.12	6.39	0.99	0.14	0.10	0.28	10.70	66	4.35	1.5	4.29

Table 3: Chemical properties of entisols at Gubi

Horizon	Depth (cm)	pH (H_2O)	Exchangeable bases Ca	Mg	K	Na	Exchange acidity	CEC	BS (%)	C	N	P
			(cmol (+) kg^{-1})							(g kg^{-1})		(mg kg^{-1})
Profile 00T1												
AP	0-28	5.96	3.80	1.00	0.08	0.38	4.92	5.40	91	3.39	1.5	2.57
Cc1	28-58	6.33	5.60	0.37	0.07	0.24	6.10	8.20	74	2.79	1.5	7.44
Cc2	58-90	6. 85	9.10	0.53	0.14	0.24	9.72	6.80	100	2.37	1.6	4.29
Cc3	90-126	6.76	6.20	0.48	0.10	0.24	6.84	5.40	100	4.79	1.4	3.60
	Mean	6.31	5.25	0.73	0.09	0.31	6.24	5.88	91	3.39	1.5	3.79
Profile 02T2/02T3												
A	0-15	5.91	10.50	2.53	0.11	0.25	0.46	13.10	100	2.79	1.2	2.04
Cc1	15-28	6.40	10.40	3.81	0.16	0.20	1.42	12.00	97	2.30	1.0	2.04
Cc2	28-62	6.36	10.20	3.01	0.04	0.12	0.54	9.50	96	2.20	0.8	0.54
Cc3	62-82	6.24	6.80	1.45	0.03	0.13	0.34	9.80	97	2.00	1.1	2.04
C4	82-121	6.73	6.60	1.52	0.04	0.12	0.36	9.30	96	2.00	1.2	0.51
C5	121-134	6.62	7.80	1.90	0.07	0.17	0.60	11.60	94	2.00	0.8	0.51
	Mean	6.20	9.36	2.38	0.08	0.20	0.45	11.55	98	2.44	1.0	1.49

Table 4: Summary of statistical analysis

	pH (H_2O)	Exchangeable bases Ca	Mg	K	Na	Exchange acidity	CEC	BS (%)	C	N	P
		(cmol (+) kg^{-1})						(g kg^{-1})			(mg kg^{-1})
Overall: LSD											
Profile	NS	NS	1.29**	NS	0.13*	3.03**	NS	NS	NS	NS	NS
Depth	0.26**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Soil type	NS	NS	NS	NS	0.10**	NS	NS	18**	NS	NS	NS

NS = Not significant, ** $p<0.01$, * $p<0.05$

Table 5: Critical limits for interpreting levels of analytical parameters

Parameter	Rating Low	Medium	High	Unit
Ca	<2	2-5	>5	cmol (+) kg^{-1}
Mg	<0.3	0.3-1.0	>1	cmol (+) kg^{-1}
K	<0.15	0.15-0.30	>0.30	cmol (+) kg^{-1}
Na	<0.1	0.10-0.30	>0.30	cmol (+) kg^{-1}
CEC (soil)	<6	6-12	>12	cmol (+) kg^{-1}
Exch. acidity	<2	2-5	>5	cmol (+) kg^{-1}
Base saturation	<50	50-80	>80	(%)
Organic carbon	<10	10-15	>50	(g kg^{-1})
Total N	<1.0	1-2	>2	(g kg^{-1})
Available P	<10	10-20	>20	(mg kg^{-1})

Source: Esu (1990) and Enwezor *et al.* (1989)

Soil pH: The soil pH values ranged between 5.6 and 6.71 (i.e., moderately acid to slightly acid) in the Alfisols and Inceptisols with the exception of profile 00T2/01T2 of the Inceptisol where the AB horizon was strongly acid (pH 5.27). The Entisols presented a unique result with the A horizon being moderately acid and the lower horizons slightly acid. There was a significant ($p<0.01$) difference in pH values with depth as shown in the tables. Soil pH was higher in the lower horizon than in the surface horizon. There were however, no significant differences between the pH values between profiles and between the soil orders. The soil pH observed in this series is likely and inherited property from the parent material-basement complex (predominantly granite).

Exchangeable acidity was generally low across the soil types and within the profiles except for profile 00T1 in the Entisols where exchangeable acidity was high with values up to 9.72 cmol (+) kg^{-1}. The high value of exchangeable acidity in profile 00T1 could be attributed to the lower organic matter content of this profile. According to Tisdale *et al.* (1985), the levels of aluminium in the soil solution also depend on the soil organic matter content and the salt content. Aluminium in the soil solution decreases as organic matter forms very strong complexes with aluminium. Exchangeable acidity values was found to be significantly ($p = 0.01$) different between profiles but was not significantly different between the soil types and depth. As stated earlier, profile 00T1 had significantly higher values that the other profiles across soil types.

Exchangeable bases: The Alfisols general contained high amounts of calcium and magnesium while the sodium and potassium contents were medium except in profile 01T3 where the potassium content was low. In the Inceptisols, calcium was high and magnesium low with the sodium content medium in profile 02T1/03T1 and low in profile 00T2/01T2. The exchangeable calcium content in the Entisols was high with medium to high magnesium content, low potassium content and medium sodium content. There were significant ($p<0.01$ and $p<0.05$) differences in the profile distribution of magnesium and sodium, respectively. The magnesium content of profiles 1.2 and 6 was not significantly different but were significantly higher than the contents in profiles 3, 4 and 5. There was also a significant ($p<0.01$) difference in the sodium content between the different soil types. The Entisols had significantly higher sodium content than the

Alfisols and Inceptisols. The generally medium to high values of calcium and magnesium in the three soil types must be an inherited property from the parent material. Brady and Weil (1999) have stated that calcium and other metallic cations are more plenty in areas of low rainfall since they are not easily leached. Bauchi is located in the semi and Savanna of Nigeria. The high sodium content of the Entisols could be attributed to the constant presence of moisture in the soil, which due to evapotranspiration draws up sodium from far depths. Additions from other soil by running water could be another reason for the high sodium content of the Entisols.

CEC and base saturation: The Cation Exchange Capacity of the Alfisols was medium to high (8.4-21.2 cmol(+) kg^{-1}) and generally medium in the Inceptisols and Entisols. There was however, no statistical ($p<0.05$) difference in the CEC values with depth, between profiles and between soil types. The Alfisols and Inceptisols had medium to high content percent base saturation (57 to 100%) and (54 to 94%) respectively. The percent base saturation for the Entisols was high with values between 74 and 100%. There was a significant ($p = 0.01$) difference in the base saturation between the three soil types. The Entilsos had significantly higher values of base saturation than the Alfisols and Inceptisols. The higher values observed in the Entisols is accounted for by the high calcium and magnesium contents which have higher strength of adsorption than H^+ which are also present in high quantities. Bauchi is in the Savanna and therefore there is no too much rainfall to leach out calcium and other metallic ions.

Organic carbon, total nitrogen and available phosphors: Organic carbon was generally low across soil type, profile and depth. This may due overgrazing, bush burning and the use of crop residues for animal feed and other domestic uses which generally help in depleting the organic matter content of the soil. The total nitrogen content was low to medium in the Alfisols and low in the Inceptisols and Entisols. Since most soil nitrogen is obtained from organic matter (aside that added through inorganic fertilization), it is not surprising that the total nitrogen content of the soils was generally low. The slight increase in content in the Alfisols may be due to the accumulated residual effects of earlier decomposed organic matter since the Alfisols are older than the Inceptisopls and Entisols. The available phosphors content was generally low across the soil types. This again is attributable to the low organic matter content of the soil, which is said to normally correlate positively with the available phosphorus content. There were no significant differences between the organic carbon, total nitrogen and available phosphorus contents of soil.

CONCLUSIONS AND RECOMMENDATIONS

The fertility status of these soils can be described as low to medium and this is attributable to the over use the land has been subjected to especially grazing and bush burning and the lack of maintenance of the soil organic matter. It is recommended that the incorporation of organic matter be intensified while grazing and bush burning should be controlled. Leguminous crops should form part of the crop rotation and inorganic fertilizers should be used for profitable crop production.

REFERENCES

Agbenin, J.O., 1995. Laboratory Manual for Soil and Plant Analysis (Selected Methods and Data Analysis). Faculty of Agriculture/Institute of Agricultural Research, ABU, Zaria, pp: 140.

Allison, L.E., 1965. Organic Carbon. In: Methods of Soil Analysis. Black, C.A. (Ed.). Part 2, American Society of Agronomy, Madison, WI, Agronomy, 9: 1367-1378.

Brady, N.C. and R.R. Weil, 1999. The Nature and Properties of Soils, 12th Edn., Prentice Hall, Upper Saddle River, New Jersey, USA., pp: 881.

Bremner, J., 1965. Total Nitrogen. In: Methods of Soil Analysis. Black, C.A. (Ed.). American Society of Agronomy, Madison, WI. USA, Agronomy, 9: 891-901.

Enwezor, W.D., E.J. Udo, N.J. Usoroh, K.A. Ayotade, J.A. Adepetu, V.O. Chude and C.E. Udegbe, 1989. Fertilizer use and mangement practices for crops in Nigeria, Series 2, Federal Ministry of Agriculture, Water Resources and Rural Development, Lagos, Nigeria.

Esu, I.E., 1991. Detailed soil survey of NIHORT farm at Bunkure, Kano State, Nigeria. Institute of Agricultural Research, A.B.U. Zaria, pp: 72.

Kparmwang, T. and I.E. Esu, 2000. Extractable forms of iron in basaltic soils of Northern Nigeria. In Press.

Mustapha, S., 2000. Characterization, classification and agricultural potential of soils along two toposequecnes on variant parent rocks in Northern Guinea Savanna of Nigeria. Unpublished Ph.D Thesis, Abubakar Tafawa Balewa University Bauchi, pp: 132.

Soil Survey Staff, 1999. Soil Survey Manual. Soil Conservation Service. U.S.D.A. Handbook No. 18. U.S. Govt. Printing Office, Washington DC.

Steel, R.C. and J.H. Torrie, 1981. Principles and Procedures of Statistics. Macmillan, New York, USA.

Tisdale, S.L., W. L. Nelson and J.D. Beaton, 1985. Soil Fertility and Fertilizers. Macmillan Publishing Co. New York, pp: 754.