EVALUATION OF SOME SOILS OF MINNA SOUTHERN GUINEA SAVANNA OF NIGERIA FOR ARABLE CROP PRODUCTION

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ABSRTACT

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The study evaluated the soils of the Teaching and Research Farm of the Federal University of Technology, Minna for arable crop production. Two dominant soil units, designated as ATRF and BTRF, were selected for this study. From each soil unit samples were collected from twelve points along diagonal transects from two depths (0 – 15 and 15 – 30 cm) and bulked to form composite samples. The samples were replicated twice and taken to the laboratory for analysis. Results showed that the texture of ATRF was sandy loam while BTRF was sandy loam on the surface over sandy clay loam on the subsurface. The silt/clay ratios of the soils were > 0.25. The soils are moderately acidic, low to medium organic carbon. The soils had medium fertility status and suitable for arable crops production but with some management practices.

INTRODUCTION

Land evaluation is a systematic process of identifying and measuring land qualities and assessing them for alternative kinds of use. The principles of land evaluation involve comparing the requirements of land use with characteristics of the land (Dent and Young, 1981). It is important that agricultural land be used according to its capacity for optimal and sustainable production (Adeboye, 1994). Soil quality has been defined as the capacity of a soil to function within ecosystem boundaries, to sustain biological productivity, maintain environmental quality and promote plant, animal and human health (Doran and Parkin, 1996). Detailed soil information on some soil types of the study site were already documented (Adeboye *et al*., 2009; Lawal *et al*., 2012). Such available soil data were mainly useful for general purposes. The objective of this study was to evaluate the soil attributes of the two dominant soil types of the Teaching and Research Farm of the Federal University of Technology, Minna for arable crops production.

MATERIALS AND METHODS

Study site

The study was carried out in the Teaching and Research Farm of the Federal University of Technology, Gidan Kwano Campus, Minna (latitude 9° 41' N and longitude 6° 31' E; 258.5 m above sea level), in the southern Guinea savanna zone of Nigeria. Climate of Minna is sub humid with mean annual rainfall of about 1284 mm and a distinct dry season of about 5 months duration occurring from November to March. The mean maximum temperature remains high throughout the year, about 33.5 ^{o}C particularly in March and June (Ojanuga, 2006). The physiographic characteristics of Minna area consist of gently undulating high plains developed on basement complex rocks made up of granites, migmatites, gneisses and schists. Inselbergs of "Older Granites" and low hills of schists rise conspicuously above the plains. Beneath the plains, bedrock is deeply weathered and constitutes the major parent material (saprolites) (Ojanuga, 2006).

Soil sampling and analysis

Two dominant soil units (ATRF and BTRF) of the Teaching and Research Farm were delineated by Adeboye, *et al.* (2009), and selected for this study. From each soil unit, samples were collected from twelve points along diagonal transects from two depths (0 – 15 and 15 – 30 cm) and bulked to form composite samples. The samples were replicated twice and taken to the laboratory. The soil samples were air dried, crushed and passed through a 2 mm sieve and some were further passed through 0.5 mm sieve laboratory analysis. Particle size analysis was determined by Bouyoucos hydrometer method (Anderson and Ingram, 1993). The soil pH was measured in water and $CaCl_2$ at 1:2.5 soil:liquid suspensions with glass electrode pH meter (Thomas, 1982). Organic carbon was determined by Walkley-Black method (Nelson and Sommers, 1982). Total nitrogen (TN) was determined by micro-Kjeldahl digestion method (Bremner, 1982). Available phosphorus (P) was extracted by Bray P1 method. Colour was developed in soil extract using ascorbic acid blue method (Murphy and Riley, 1962). Exchangeable bases, calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na) were extracted with 1N NH_4OAC. Calcium and Mg in the extract were determined using atomic absorption spectrophotometer (AAS) while K and Na was determined by flame photometry. Exchangeable acidity was determined titrimetrically as described by Udol *et al.,* (2009). The effective cation exchange capacity (ECEC) was determined as the summation of total exchangeable bases plus exchangeable acidity as described by Udol *et al.,* (2009). The percentage base saturation was calculated as percentage of exchangeable bases divided by effective cation exchange capacity as described by Udol *et al.,* (2009).

RESULTS AND DISCUSSION

Some physical properties of the soils are shown in Table 1. Sand was the dominant mineral component in the study soils. Its content ranged from 725 to 765 g kg^{-1} in ATRF and from 684 to 725 g kg^{-1} in BTRF. The clay content ranged from 133 to 152 g kg^{-1} in ATRF and from 182 to 242 g kg^{-1} in BTRF

Table 1: Physical properties of soils of the study area

Soil Unit	Soil Depth (cm)	Sand	Silt	Clay	Textural class	Silt/clay
		g kg^{-1}				
ATRF 1	0-15	745	103	152	Sandy loam	0.68
	15-30	725	123	152	Sandy loam	0.81
ATRF 2	0-15	765	102	133	Sandy loam	0.77
	15-30	760	98	142	Sandy loam	0.69
BTRF 1	0-15	725	93	182	Sandy loam	0.51
	15-30	685	73	242	Sandy clay loam	0.30
BTRF 2	0-15	705	113	184	Sandy loam	0.62
	15-30	684	102	214	Sandy clay loam	0.48

Table 2: Chemical properties of the soils of the study area

Soil unit	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	OC (g kg^{-1})	Total N (g kg^{-1})	Available P (mg kg^{-1})	Exchangeable bases Ca	Mg	K	Na	Exchangeable acidity	ECEC	Base saturation (%)
							(cmol kg^{-1})						
ATRF1	0 – 15	5.7	4.8	10.80	0.77	16	2.33	0.75	0.28	0.65	1.23	5.24	77
	15 - 30	6.2	4.9	10.00	0.74	11	2.08	0.58	0.25	0.48	1.00	4.39	77
ATRF 2	0 – 15	6.1	4.6	11.10	0.84	20	3.17	1.42	0.64	0.57	1.00	6.80	85
	15 - 30	6.4	4.5	11.50	0.88	19	2.92	1.25	0.47	0.89	0.62	6.15	90
BTRF 1	0 – 15	6.3	4.9	12.00	1.26	17	2.25	1.08	0.13	1.26	0.62	5.34	88
	15 – 30	6.2	5.0	11.70	0.88	14	2.33	1.92	0.23	1.05	1.53	8.01	81
BTRF 2	0 – 15	6.1	5.1	8.30	0.64	19	2.62	1.92	0.33	0.96	1.50	7.38	80
	15 – 30	6.6	4.7	7.40	0.39	17	2.00	1.17	0.27	1.01	1.23	5.68	78

OC = Organoc carbon, N = Nitrogen, P = Phosphorus, Ca = Calcium, Mg = Magnesium, K = Potassium, Na = Sodium

Table 3: Critical limits for interpreting levels of soil nutrients

Parameter	Low	Medium	High
Ca^{2+} (cmol kg^{-1})	< 2	2 – 5	> 5
Mg^{2+} (cmol kg^{-1})	< 0.3	0.3 – 1	> 1
K^{+} (cmol kg^{-1})	< 0.15	0.15 - 0.3	> 0.3
Na^{+} (cmol kg^{-1})	< 0.1	0.1 - 0.3	> 0.3
CEC (cmol kg^{-1})	< 6	6 – 12	> 12
Org. C (g kg^{-1})	< 10	10 – 15	> 15
Total N (g kg^{-1})	< 0.1	0.1 – 0.2	> 0.2
Avail. P. (mg kg^{-1})	< 10	10 – 20	> 20
B.S (%)	< 50	30 – 80	> 80

Source: Esu (1991)

The sand content of the soils were relatively high, while the silt and clay particles were fairly low. The low silt/clay ratios suggest that the soils were young and subjected to low degree of weathering as previously reported by Ezenwa (1987) on similar soils. The chemical properties of the soils are shown in Table 2. The soil pH ranged from 5.7 to 6.4 in ATRF and from 6.1 to 6.6 in BTRF. The moderate acidic nature of the soil could be attributed to moderate rainfall and that leaches basic cations (Beets, 1990). The low pH may also be associated with their silica rich parent materials (Ojanuga, 2006). The results imply that some plant nutrients may be more readily available in the soils of the study area. The difference between the pH in water and $CaCl_2$ was fairly large implying a large amount of surface available for cation adsorption (Ogban *et al.*, 2004). Organic carbon content ranged from 10.00 to 11.50 g kg^{-1} in ATRF rated medium (Esu, 1991), and from 7.40 to 12.00 g kg^{-1} in BTRF. The BTRF 2 was rated low (Esu, 1991). The organic content in all the soils decreased with depth except in soil unit ATRF 2. These results may be attributed to the concentration of plant roots in the surface horizon with very few or no roots in the lower horizons. The mineralization of plant roots increases the soil organic carbon contents.

The low level of the organic carbon corresponded with previous report for savanna soils by Esu (1989). The medium to low values of the organic carbon might be partly attributed to the rapid organic matter mineralization, thereby preventing any appreciable level of accumulation and due to poor management of the farmer Greenland *et al*., (1992). It may also reflect the sparse natural vegetation of the area and cultural practice of crop residues removal and has implication for the stabilization of soil aggregate and the environment.
Available phosphorous was medium in the soils. The medium content of available phosphorous in the soils could be attributed to the fallow. The nitrogen ranged from 0.77 to 0.88 g kg^{-1} in ATRF and from 0.39 to 1.26 g kg^{-1} in BTRF. Exchangeable bases in terms of abundance occur in the order Ca> Mg > Na > K in the soil, the exchangeable Ca is the least easily lost from the soil environment (Bray and Weil, 2010). The high to medium content of exchangeable Ca, Mg and K in all the soils could be attributed to pedochemical weathering of the parent material containing the respective base–bearing materials in addition to reduced leaching losses. The low values of effective cation exchange capacity might be attributed to low clay and organic carbon content of the soils of the study area. The high base saturation of the soils indicates that the exchangeable bases have dominance over exchangeable acidity.

CONCLUSION

The soils had medium fertility status and suitable for arable crops cultivation but requires some management practices for optimum crop production.

REFERENCES

Adeboye, M. K. A. 1994. The physicochemical properties and evaluation of Kaduna Polytechnic Farm soils for arable cropping. *Spectrum Journal*. 1:36 – 44,

Adeboye, M. K. A., Osunde, A. O., Ezenwa, M. I. S., Odofin, A. J. and Bala, A. 2009. Evaluation of the fertility status and suitability of some soils for arable cropping in the southern Guinea savanna of Nigeria. *Nigerian Journal of Soil Science.* 19(2): 115-120.

Anderson, J. M. and Ingram, J. S. 1993. Tropical soil biology and fertility. A handbook of methods. Information press Eynsham.

Beets, W. C. 1990. Raising and sustaining productivity of small farming system in the tropics. Agbe publishers, Alkmaar Netherlands pp 175 – 291.

Brady, N. C. and Weil, R. R. 2010. The nature and properties of soils, 13th edition Prentice Hall Inc. New Jessey, U.S.A. Pp 960.

Bremner, J. M. 1982. Inorganic nitrogen. In page A. L, Miller, R. H and Keeney, D. R. (eds). Methods of soil analysis. Part II 2nd edition. *America Society of Agronomy*. Madison Wiscosin.

Dent, D. and Young A. 1981. Soil survey and land evaluation. London, England: George Allen and Unwin. S 592. 14. D41 Mann.

Doran, J. W. and Parkin, T. B. 1996. Quantitative indicators of soil quality: a minimum data set. In: Doran, J.W., Jones, A.J. (Eds.), Methods for Assessing Soil Quality. SSSA Special Publication, Vol. 49. Soil Science Society of America, Madison, WI, USA, pp25 – 37.

Esu, I. E. 1989. Pedological characterization of the soil of the Hadejiya alluvial complex in the semi arid region of Nigeria.xxxix 179 – 190.

Esu, I. E. 1991. Detailed soil survey of NIHORT Farm at Bunkure, Kano State, Nigeria. Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria. 72 pp.

Ezenwa, M. I. S. 1987. Some physicochemical characteristics of soil of basement complex adjoining basaltic rocks of northern part of Nigeria in the proceeding of the 15th annual conference of Soil Science Society of Nigeria, pp 205 – 214.

Greenland, D. J., Wild, A. and Adams, D. 1992. Organic matter dynamics in soils of the tropics – from myth to reality. In: Lal, R. and Sanchez, P. A. (eds.). myths and science of soils in the tropics. Soil Science Society of America, Madison, pp17 – 39.

Lawal, B. A., Odofin., A. J. Adeboye, M. K. A. and Ezenwa, M. I. S. 2012. Evaluation of selected fadama soils in Katcha Local Government Area of Niger State for arable cropping. *Nigerian Journal of Soil Science.* 22 (2): 104-111.

Murphy, J. and Riley, J. P. 1962. A modified single solution method for the determination of phosphorous in natural water. Analytical Chimica ACTA. 27: 31 – 36.

Nelson, D. W. and Sommers, L. S. 1982. Total carbon, organic carbon and organic matter. In Page, A.L. et al., Agronomy Monogram 9 (2nd edition). P. 403 – 430. ASA and SSSA. Madison, Wisconsin.

Ogban, P. I., Ukpong, U. K. and Essein, I. G. 2004. Interrelationship between bush fallow and the physical and chemical properties of 'acid' sands in southeastern Nigeria. *Nigerian Journal of Soil Research* 5: 32 – 43.

Ojanuga, A. G. 2006. Agroecological Zones of Nigeria Manual. FAO/NSPFS, Federal Ministry of Agriculture and Rural Development, Abuja, Nigeria, 124 pp.

Omar, G. 2011. Assessment of the fertility status of some irrigated Fluvisols in Northern Guinea Savannah of Nigeria. *Savannah Journal of Agriculture*. 6(1):19 – 31.

Thomas, G. W. 1982. Exchangeable cations method of soil analysis. Part II *Agronomy Monograph* 9. 3rd edition of ASA and SSSA, Madison Wisconsin.

Udo, E. J., Ibia, T. O., Ogunwale, J. A., Ano, A. O. and Esu, I. E. 2009. Manual of soil, plant and water analysis, Sibon books LTD, flat 15, blk. 6, fourth avenue Festac, Lagos.

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