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Evaluation of the Effects of Selected Agricultural Land Utilization Types on Soil Properties in Nando Southeastern Nigeria

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Abstract: The study was conducted to evaluate the effects of selected land use types on soil properties in Nando, Anambra State, Southeastern Nigeria. Four land use types (cassava farm, bush fallow, oil palm and rice farm) spread over Nando were chosen for the study. A free soil survey technique aided field sampling. Soil profile pits were dug, characterized and described. Soil samples were subjected to routine laboratory analyses. Soil data were subjected to correlation and regression analysis. Results showed variations in soil properties with soils under fallow containing higher amounts of organic matter and total nitrogen. There was significant (p=0.05) positive correlation between organic matter and pH (r=0.75*), total nitrogen and organic matter (r=0.82*) while negative correlation existed between pH and aluminum (r=-0.58*).

Key words: Tropical soil % Land use types % Soil properties

INTRODUCTION

Heterogeneity in soil properties originated from combined influences of chemical, biological and physical processes that operate with different intensities and at different scales. Certain edaphic and agronomic factors vis-à-vis soil physical and chemical properties govern the fertility status of the soil [1], others such as soil aggregate stability [2], soil moisture availability [3] and general soil quality [20] equally contribute. Variations in soil properties under similar agro-ecological zone may be as a result of parent materials [5], landscape position, land use and cultural practices [6], topography, vegetation are among these factors.

Before late 1980's, bush fallowing was a measure farmers in Nando adopted to restore the fertility status of the soils that had been cultivated for some years. During this period, three (3) years of cropping were followed by eight (8) years of bush fallow, but increasing population pressure has forced farmers to reduce the length of fallow to three years. This as anticipated would result in decline of soil fertility and productivity.

The information obtained from the characterization of soils would enable farmers to rationally plan the development and use of the lands accordingly, so as to put available agricultural lands to their best uses for sustainable food production. This has, therefore, necessitated this study with the objective of investigating the properties of soils under different land use types.

MATERIALS AND METHODS

Study Area: Nando in Anambra State of Southeastern Nigeria is located between latitude 5°25\ - 5°4\\ N and longitude 6°55\-7°5\\E. Soils are derived from Coastal Plain Sands. It is a humid tropical environment with an average annual rainfall of 1500 to 2500 mm and mean monthly temperature varying between 20°C and 35°C. Farming is a major socio-economic activity. Land clearing is by slash-and-burn technique while soil fertility regeneration is by bush fallowing whose length has decreased due to anthropogenic activities.

Field Studies: A free soil survey technique was used in field work. Four land use types were studied. A profile pit was dug in each of the land use types, given a total of four profile pits that were described based on the guideline of [7]. Soil samples were collected from the bottom most layer upwards according horizon differentiation. A total of 16 samples were collected. Soil samples were air dried, crushed and sieved using a 2mm sieve.

Laboratory Analysis: Particle size distribution was determined by hydrometer method [8]. Soil pH was measured using 1:2.5 soil –water ratio [9]. Organic matter was determined by wet digestion method [10]. Available P was estimated using Bray-P II method [11]. Total nitrogen was determined by kjeldah digestion method

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[12]. Soil exchangeable bases were determined by the neutral ammonium acetate procedure. Exchangeable acidity was measured in l N KCl [13].

Soil data were subjected to mean statistic, relationship between selected soil properties were obtained using correlation and regression analysis.

RESULTS AND DISCUSSION

The particle size distribution of the soils under different land use types are shown in Table 1. Soils of the study area were sandy loam, with soils under bush fallow containing higher amount of sand and silt, respectively. Sandiness of soils could be as a result of the combined effects of parent materials, land use and climate which alter the pedogenesis of soils. Generally, clay increased with depth indicating argillation or clay lessivage [14].

The pH values of the soils ranged from moderately acidic (5.23) to slightly acidic (6.78). Soils from fallow lands had ideal pH for crop production and nutrient availability. Low pH values observed in soils from oil palm, cassava and rice farms, which could be attributed to the effects of inorganic fertilizers used in crop production, leaching of basic cations following high intensity of rainfall prevalent in the region, porous nature of the soils and the accumulation of aluminum ions. This finding corroborates the report of [2] who stated that soils under continuous cassava cropping and oil palm plantation have low pH. In acidic soils, the abundance of iron and aluminum results to net reduction in pH [15].

Total exchangeable bases varied from 2.07 to 2.99 cmol/kg. The relatively low exchangeable cations recorded in the soils of Southeastern Nigeria may be attributed to leaching process that occurs as a result of high intensity of rainfall in the region [11].

However, the low concentrations of basic cations observed in this study could be attributed to nutrient uptake by plant without adequate manuring and/or fertilizing for replacement. Nnaji *et al.* [6] and Olson and Sommers [17] reported low exchangeable basic cations in some soils of Southeastern Nigeria.

Table 1: Particle size distribution and textural classification of soils under different land use types

Land Use Types	Horizon	Depth (cm)	Clay (g/kg)	Silt (g/kg)	Sand (g/kg)	Textural class	Silt/clay
			Profile 1				
Cassava farm	A	0-13	95.00	220.00	685.00	SL	2.32
	BA	13-40	137.00	128.00	735.00	SL	0.93
	Bt1	40-75	140.00	120.00	740.00	SL	0.86
	Bt2	75-160	146.00	100.00	754.00	SL	0.68
		Mean	129.00	142.00	728.00	SL	
			Profile 2				
Bush fallow	A	0-15	59.00	273.00	668.00	SL	4.63
	B	15-50	90.00	145.00	765.00	LS	1.61
	Bt1	50-82	90.00	160.00	750.00	LS	1.78
	Bt2	82-140	110.00	125.00	765.00	SL	1.14
		Mean	87.50	175.75	736.75	SL	
			Profile 3				
Oil palm	A	0-15	96.00	230.00	674.00	SL	2.40
	AB	15-42	156.00	120.00	724.00	SL	0.77
	Bt1	42-80	157.00	110.00	733.00	SL	0.70
	Bt2	80-150	165.00	110.00	725.00	SL	0.67
		Mean	143.00	142.00	715.00	SL	
			Profile 4				
Rice farm	A	0-14	47.00	138.00	815.00	LS	2.94
	B	14-40	146.00	130.00	724.00	SL	0.89
	Bt1	40-71	176.00	140.00	684.00	SL	0.80
	Bt2	71-150	185.00	130.00	685.00	SL	0.70
		Mean	138.50	134.50	727.40	SL	

SL: Sandy loam, LS: loamy sand

Table 2: Some chemical properties of soils under different land use types

Land Use Types	Horizon	Depth (cm)	pH H_2O	Ca	Mg	K	Na	TEB	Al	H	EA	CEC	OM	TN	Av.P	BS	Alsat
				cmol kg^{-1}									g/kg		mg/kg	%	
							Profile 1										
	A	0-13	5.22	2.00	0.63	0.06	0.07	2.76	0.56	0.18	2.51	5.27	19.60	6.50	1.84	52.37	10.62
	BA	13-40	5.67	1.58	0.50	0.06	0.06	2.20	0.86	0.13	2.48	4.68	7.20	0.30	0.40	47.00	18.37
Cassava farm	Bt1	40-75	5.07	1.920	0.67	0.06	0.07	2.72	0.56	0.05	3.47	6.19	15.50	0.60	1.20	43.94	9.04
	Bt2	75-160	5.65	2.00	2.13	0.06	0.07	4.26	0.82	0.11	2.49	6.75	16.20	0.60	1.00	63.11	12.15
		Mean	5.40	1.88	0.98	0.06	0.07	2.99	0.70	0.47	2.75	5.72	14.63	2.00	1.11	51.60	12.55
							Profile 2										
	A	0-15	5.93	2.12	0.38	0.06	0.05	2.61	0.2	0.05	0.91	3.52	40.90	12.00	0.40	74.15	5.68
	B	15-50	6.68	2.00	0.67	0.05	0.06	2.78	0.11	0.01	0.48	3.26	18.90	12.00	0.80	85.26	3.37
Bush fallow	Bt1	50-82	7.08	2.11	0.58	0.06	0.05	2.80	0.09	0.01	0.21	3.01	12.00	0.90	0.80	93.00	2.99
	Bt2	82-140	7.42	2.08	0.67	0.06	0.07	2.88	0.10	0.01	0.05	2.93	15.50	10.00	1.80	98.20	3.46
		Mean	6.78	2.08	0.58	0.06	0.07	2.77	0.13	0.02	0.41	3.18	21.83	8.70	0.95	63.35	3.88
							Profile 3										
	A	0-15	5.27	0.95	0.05	0.05	0.02	1.07	0.42	0.01	1.90	2.97	0.80	1.40	1.20	36.00	1.41
Oil palm	AB	15-42	5.32	0.89	0.15	0.05	0.04	1.13	0.85	0.21	2.01	3.14	0.70	0.60	1.84	35.98	27.07
	Bt1	42-80	5.16	2.92	0.35	0.07	0.03	3.37	0.49	0.05	2.56	5.93	0.40	0.90	1.84	56.83	8.20
	Bt2	80-150	5.36	1.90	0.68	0.06	0.05	2.69	0.90	0.03	2.01	4.70	0.40	10.00	1.29	57.23	19.14
		Mean	5.23	1.67	0.38	0.05	0.05	2.07	0.67	0.08	2.12	4.19	0.56	0.98	1.54	46.51	13.96
							Profile 4										
	A	0-14	5.28	1.20	0.1	0.06	0.03	1.39	0.50	0.05	1.79	3.18	25.10	0.90	1.20	43.71	15.72
Rice farm	B	14-40	5.35	2.40	1.40	0.06	0.05	3.91	0.14	0.02	1.40	5.31	23.60	0.50	1.20	73.64	2.60
	Bt1	40-71	5.95	1.95	0.35	0.06	0.06	2.36	0.10	0.05	0.99	3.35	8.90	0.40	0.60	70.44	2.99
	Bt2	71-150	5.59	1.51	0.50	0.06	0.04	1.66	0.51	0.05	1.31	2.97	1.62	0.60	1.00	55.89	17.17
		Mean	5.79	1.77	0.59	0.06	0.05	2.33	0.31	0.04	1.37	3.70	14.80	0.60	1.00	60.92	9.62

TN = total nitrogen, OM= Organic matter, EA= Exchangeable acidity, CEC= cation exchange capacity, BS = base saturation, Al = aluminum, Alsat = aluminum saturation, Av.P = Available phosphorus

Table 3: Correlation between some soil properties (p = 0.05)

Soil properties	Correlation coefficient (r)
pH versus organic matter	0.75*
Potassium versus total nitrogen	0.24^{ns}
Alsat versus base saturation	-0.79*
pH versus Al^{+3}	-0.58*
Sodium versus organic matter	0.31^{NS}
Organic matter versus total nitrogen	0.82*
Calcium versus pH	0.64*

* = Significant at p=0.05 level of probability, NS = not significant

Results showed that exchangeable calcium dominated the exchange site among the basic cations in all the land units (Table 2). This finding is in agreement with the reports of [18] and [19]. The distributions of exchangeable cations have varying influence on soil properties. Braver et al.,[18] stated that calcium act as a link between clay particles and organic polymers, which increase aggregate stability of the soils.

Available phosphorus ranged between 0.87 and 1.54 mg/kg. Considering the critical value for phosphorus in soils of Southeastern Nigeria, which is 15 mg/kg for Bray P-II [20], the soils under the various land use types studied may require phosphate fertilizer application for sustainable crop yield.

Soil organic matter contents of the soil ranged from 0.56 to 21.83 g/kg with soils from fallow land having

higher amount of organic matter (Table 2). High organic matter (OM) recorded in soils under fallow is not unusual since the fallow contained different plant species that constituted litter which is relatively high in OM content. Rapid decomposition of the plant materials enhances the quantity of OM present in the soil that were obtained in soils from cassava and oil palm farms may be attributed to loss of OM due to high intensity of cultivations and leaching. Similarly, soils under fallow had high concentration of nitrogen which could be a reflection of OM content of the soils.

The percentage base saturation ranged from 46.51 to 63.35 %. Generally, low base saturation was observed in all the land units studied which could be attributed to high aluminum saturation and low exchangeable basic cations present in the soils.

Significant positive (p = 0.05) relationship was observed between OM and nitrogen (r = 0.82*), pH and OM (r = 0.75*), calcium and pH (r = 0.64*) (Table 3). A negative significant correlation existed between aluminum and pH (r = - 0.58*), base saturation and aluminum saturation (r = -0.79*) respectively (Table 3).

CONCLUSION

From the study, it was ascertained that heterogeneity existed in the properties of soils under different land use types with soils from fallow land possessing superior agronomic potentials. The distributions of most of the soil properties were inconsistent down the profile pits showing sparing influence of depth on the study. Apart from the four land use types studied, further investigation on the characterization of soils under other agricultural land utilization types may be necessary for the purpose of ascertaining suitable land use types for sustainable soil quality productivity.

REFERENCES

1. Braver, I.D., W.H. Gardner and W.R. Gardner, 1978. Soil physics. Fourth edition John Willey and Sons. New York, pp: 498.
2. Bremner, J.M. and C.S. Mulvaney, 1982. Total-Nitrogen. In: Methods of Soil analysis, Part 2. Eds., Page, A.L., R.H. Mille and D.R. Keeney. American Society of Agronomy Madison, W1, pp: 595-624.
3. Enwezor, W.O., A.C. Ohiri, E.E. Opuwaribo and E.J. Udo, 1990. Literature Review on Soil Fertility Investigation in Nigeria. Federal Ministry of Natural Resources Lagos.
4. Eshett, E.T., A.I. Omueti and A.S.R. Juo, 1990. Physico-chemical, Morphology and Clay Mineralogical Properties of Soils overlying Basement Complex Rocks in Ogoja, Northern Cross River State of Nigeria. Soil Science and Plant Nutrition, 36(2): 203-14.
5. Esu, I.E., 1999. Fundamentals of pedology. Stirling-Horden publishers (Nig) Ltd, Ibadan, pp: 1330.
6. FAO (Food and agricultural organization), 1990. Guidelines for Soil Profile Description 3rd edition. FAO. Rome, pp: 70.
7. Foth, H.D., 1984. Fundamentals of Soil Science, 7th edition John Willey and sons. New York, pp: 498.
8. Gee, G.W. and D. Or, 2002. Particle Size Analysis. In: Methods of soil analysis, part 4. physical methods. Eds., Dane, J.H. and G.C. Topp. Soil Science Society of America. Book series . No. 5 ASA and SSA Madison, W1, pp: 255-293.
9. Gruhn, P., F. Goletti and M. Yudelman, 2000. Integrated Nutrient Management, Soil Fertility and Sustainable Agriculture. IFPRI, Discussion paper Washington D.C., pp: 31.
10. Idigbor, C.M., D.O. Asawalam and O.O. Agbede, 2008. Phosphorus Forms and P sorption Capacity of Fauna Modified Soils of Southeastern Nigeria. J. Agricultural Production and Technol., 4(2): 190-106.
11. Mclean, E.C., 1965. Aluminium. In: Method of Soil Analysis, Ed., C.A. Blacks. Agronomy No. 9 part 2 American Society of Agronomy, Madison Wisconsin.
12. Ndukwu, B.N., C.M. Idigbor, S.U. Onwudike, P.O. Okafor and S.K. Osuaku, 2009. Spartial Variability in some Properties of Soils formed under different Lithologies in Southeastern Nigeria. In the Proceeding of the 5th National Conference of Organic Agriculture Project in Tertiary Institution in Nigeria, pp: 94-97.
13. Nelson, D.W. and L.E. Sommers, 1982. Total Carbon, Organic Carbon and Organic Matter. In: Methods of Soil Analysis, Eds., Page, A.L., R.H. Mille and D.R. Keeney. American Society of Agronomy Madison, W1, pp: 539-579.
14. Nnaji, G.U., C.I.A. Asadu and J.S.C. Mbagwu, 2002. Evaluation of Physical-chemical Properties of Soils under selected Agricultural Land Utilization Types. Agro. Sci., 3: 27-33.
15. Olson, S.R. and L.E. Sommers, 1990. Phosphorus. In: Methods of Soil Analysis. Parts 2, Ed., Page, A.L. Agron., Monogr. No. 9 Madison, WI, pp: 403-431.

16. Onweremadu, E.U., F.O.R. Akamigbo and C.A. Igwe, 2007. Physical Shrinkage Relationship in Soils of Dissimilar Lithologies in Central Southeastern Nigeria. J. Appl. Sci., 7(17): 2495-2499.
17. Opara, C.C., 2007. Soil Macro Aggregate Stability under different Land Use Types in Imo State, Southeastern Nigeria. International J. Agriculture and Rural Development, 9: 22-29.
18. Oti, N.N., 2007. Assessment of Fallow as a Natural Strategy to Restore Erosion degraded lands. International Journal of Agriculture and Rural Development, 9: 32-39.
19. Seybold, C.A., R.B. Grossman, H. Hoper, G. Muckel and D.L. Karien, 2004. Soil Quality Morphological Index Measured in 1996 NRI Pilot Study. Soil Survey Horizon, 45: 86-95.
20. Thomas, G.W., 1996. Soil pH and Soil Acidity. In: Methods of soil analysis, part 3- chemical methods. Ed., L.D. Sparks. Soil Science Society of America, Book Series. No 5.