African Research Review

An International Multi-Disciplinary Journal, Ethiopia
Vol. 4 (4), Serial No. 16, October, 2010
ISSN 1994-9057 (Print) ISSN 2070-0083 (Online)

Soil Characterization and Land Use of Arondizogu Inland Valley in Imo State Nigeria *(Pp. 471-481)*

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Abstract

The soils Arondizogu inland valley were characterized by investigating their morphological, physical and chemical properties. Also studied were the land use activities of the area. Soil colour was dark brown in the dry upland and gray in the wet valley bottom. Soil texture varied from sandy clay loam in the surface soil to clay in the subsoil. The pH of the soils were strongly to moderately acidic (4.7-5.8); total N were poorly supplied (0.03-0.30%); organic carbon was low to moderate (0.3-3.5%) the values decreased with depth. Effective cation exchange capacity was low (4.60-6.39 meg/100g). Similarly, exchangeable acidity was generally low in the surface soil but increased with depth. The upland areas are used for yam based crop mixture (YBCM) on mound while the valley bottom is restricted to a monoculture of rainy season rice production on flat seedbeds. Higher crop productivity in the area requires fertilizer input, improved crop varieties and use of ridges to check soil erosion.

Introduction

Agriculture is the predominant land use activity in Imo state of Nigeria and seventy five percent of the inhabitants of this state are engaged in it. As a result of demographic pressure on static land resources the traditional land use system (shifting cultivation) was abandoned and rotational bush fallow system adopted (Van de Kerk, 1988). The productivity of the rotational bush fallow system has within the past two to three decades been drastically reduced following continuous decrease in fallow periods. Farmers are now compelled to cultivate steeper, more fragile or even marginal lands where over exploitation has led to high rate of deforestation, soil erosion and declining productivity. Also, some soil related factors have contributed to the declining productivity of the current agricultural land use system such as low pH, and low plant nutrient reserve.

One way of addressing this problem is the exploitation of inland valleys abundant in the area. Hydromorphic lowlands have a higher potential for intensification and diversification of agricultural production than the uplands (Windmeijer and Jamin, 1996). The potential yields of crops in inland valleys are significantly higher than in upland fields (Jagtap, 1993). The objectives of this study were to characterize the soils of Arondizogu inland valley which is underlain in shale ;one of the major parent rock in the state, and also to assess the land use activities in the inland valley with a view to identifying constraints to arable crop production in the area.

Materials and Methods

The study area

The study area is shown in Fig. 1.0. Arondizogu inland valley is underlain by the Imo Shale Formation (Ofomata, 1995). The climate is tropical with two main regimes – a dry season and a wet season. The area has mean annual rainfall of 1933 mm and a mean annual temperature of 26.6 ^{o}C.

Field study

Three pedons; GO4, GO5 and GO6 representing the crest, mid-slope and valley bottom were prepared. The detailed summary of the soil physical characteristics and profile of the area are presented in Appendix 1. The field work procedures were carried out as explained in soil survey manual (Soil survey Staff, 1951). Land use activities within the physiographic units were also studied.

Laboratory Analysis

Particle size analysis was done by hydrometer method (Bouyoucos, 1962): bulk density was by the core procedure (Blake, 1965).

Soil pH was determined in both distilled water and in KCl (1:2) using a glass electrode pH meter. Organic matter was measured by the wet oxidation method (Walkley and Black, 1934).

Total N was determined by the modified micro-Kjeldahl procedure (Bremner, 1965). Available P was extracted by the Bray No.2 extractant (Bray and Kuntz, 1945). Exchangeable bases were determined by the neutral ammonium acetate displacement procedure (Jackson, 1958). Calcium and Mg in the extract were determined with AAS while Na and K were estimated by flame emission spectrophotometry.

Exchangeable acidity was determined by the 1M KCl extraction method (Mclean, 1965). Effective cation exchange capacity was computed by adding the exchangeable bases and the exchangeable acidity (Jackson, 1962).

Results and Discussion

The soil profiles are described in the Appendix while Tables 1 shows some selected soil properties. Soil textures vary from clay loan to sandy clay loam in the A horizon and from sandy clay loam to clay in the B-horizon. The fine texture of the soils could be attributed to the influence of the parent rock (shale) underlying the study site. The clay content is high (23.1-73.2%) and increased with depth (Table 1.0). The clay increased between the eluvial and illuvial horizons ranging from 26.2 to 43.5 % in all the pedons and occurred within a distance of 19 cm. In addition, illuvial/ eluvial clay ratio for Pedon GO5 was 2.13. These results supported the basis for suggesting the occurrence of clay movement and the formation of argillic horizon (Soil Survey Staff, 1975).

Apart from having strong influence on aggregate stability, the high clay content could also cause poor internal drainage and water logging; a condition not favourable for the growth and development of tuber crops.

Topsoil bulk density ranged from 1.29 to 1.44 g/cm^3. This low range indicates that the soils are non-compacted. The subsoil value (1.5-1.68 g/cm^3) increased with depth. This phenomenon could be a consequence of decreasing organic matter content with depth, less aggregation and root penetration, and compaction caused by the weight of overlying layers.

The soil pH (in H_2O) ranged from 4.7 to 5.8. Pedon GO6 had higher pH value probably because of its position in the toposequence which makes it act as a sink for basic cations leached from the upland areas. Delta pH (KCl- pH H_2O) was negative in all the Pedons portraying the occurrences of net negative charges which is evidence by the presence of variable charge colloids such as sesqioxides.

The organic carbon as a measure of organic matter content (Periaswamy et al.,1982) were 2.93 %, 2.34% and 3.50% for the A horizons of Pedons GO4, GO5 and GO6 respectively. These values decreased sharply with depth, with values ranging from 0.3 to 1.61 % in the subsoil. The higher values obtained for the surface horizons are probably because of organic matter accumulation in the layer.

Total N contents were poorly supplied to the soils (0.03-0.30 %) with surface soils having higher values. The element strongly correlated with organic matter (r=0.92), the carbon: nitrogen ratio was low, ranging from 8.00 to 16.71. However, the soil can still respond to N fertilization. Available P content varied from 7.58-12.6 ppm for the topsoil decreasing with depth to a minimum of 1.22 ppm. There was a strong correlation (r= 0.81) between P and organic matter. Pedon GO6 had higher P values than the other pedons and this can be attributed to the reduction of ferric phosphate into more soluble ferrous phosphate (White, 1979).

Total exchangeable bases ranged from 4.53-8.13 meq/1000g in the A horizon and from 2.60-4.77 meq/100g in the B horizon. Generally, the surface soils had higher exchangeable bases and this could be linked to litter accumulation in this layer. This is further corroborated by the strong correlation (r=0.96) between organic matter and TEB. The exchange sites were dominated by Ca but since most of the horizons had less than 3.48 meq/100g of soil, the element could still be said to be limiting (Adepetu et al., 1979).

Effective cation exchange capacity was low (4.60-9.06 meq/100g of soil). In consonance with the organic matter distribution, the surface soils had higher values and the ECEC positively correlated (r=0.49) with the organic matter. The low ECEC is an evidence of leaching of bases under the high rainfall regime. Exchangeable acidity was generally low in the surface soils increasing with depth. The values ranged from 0.89-2.12 meq /100g of soil. Aluminium saturation of the adsorption complex was low in the topsoils but increased with depth also. The low level of Al saturation reported for the topsoil showed that the horizons were not extremely acidic; a fact supported by moderate to high base saturation. However, by having Al saturation > 20% in the subsoils of pedons GO4 and GO5, these horizons have the potential of being toxic.

Land use

Agriculture is the major land use activity in the study area. The upland (crest and mid-slope) areas are used for yam based crop mixture (YBCM) and cassava based crop mixture (CBCM), on mounds. The valley bottom is used for a monoculture of rice production on flat seed bed in the rainy season.

Crop composition for the YBCM were yam *Discorea spp* as the principal crop, cassava *Manihot esculenta*, cocoyam *Colocasia esculenta*, maize Zea mays, and vegetables such as melon (*Citrullus vulgaris),* pumpkin (*Telfaria occidentalis,)* okra (*Hibiscus esculentus)* etc. in CBCM (Cassava as the key crop), the above mentioned crops are also cultivated except yam.

There were fallow plots with poor floristic composition. Available plants include *Eupatorium spp*, *Pennistum purpureum*, and Impereta *cylindrica.* Also present were scattered stands of tree crops such as *Elaesis guneensis*, *Dacryodis edulis*, *Treculia africanan*, *Parkia clappertonia* etc. Fallow period vary from 2-4 years.

The upland area is 'dry' consequent upon its slope condition which makes it difficult to accumulate water. The soil moisture regime is conducive for the production of the above mentioned arable crops. However, the low nutrient status of the soil coupled with the use of local crop variety result in low yields. This condition is exacerbated by cultivation on mounds in the erosion prone steep slopes. Mounds are not effective in controlling erosion.

The valley bottom is used for a monoculture of rice (*Oryza sativa*) production in the rainy season on flat seedbeds. The wetland area, although relatively more fertile than the upland areas, is not used for the production of such principal crops as yam and cassava because of low tolerance of the crop for poor drainage. The unit highly suits swamp rice due to the abnormal requirement of the crop, arising from its physiological need for standing water during part of the year.

Conclusion

The soil physico-chemical properties of Arondizogu inland valley are partly influenced by the shale parent rock and partly by high rainfall regime of the area. Although shale has been reported to confer high nutrient status on soils that was not the case in the present study probable because of the effect of high rainfall which causes leaching, and run off that transport nutrient materials away. Relatively, the valley bottom had higher nutrient status because of its physiographic position.

To improve on the arable crop production in the area, there is a need to incorporate organic manure application in the soil management strategy for the area. Not only will this add plant nutrient to the soil but also improve soil physical properties. In addition, ridge should be used rather than mounds for erosion control purpose, coupled with the introduction of improved crop varieties. The full potential of the valley bottom can further be utilized by practicing dry season vegetable production because of the high water table and the soils ability to retain moisture during the dry period.

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Table 1.0. Physical Properties of soil of Arondizogu Inland Valley

Horizon	Depth (cm)	BD (gcm^3)	Particle size distribution sand (%)	Silt (%)	clay (%)	silt/silt+ clay ratio	Textural class
	PEDON GO4		CREST				
A	0-16	1.29	48.5	21.4	30.1	0.42	clay loam
AB	16-42	1.59	26.1	11.6	62.3	0.16	clay
B1t	42-85	1.64	16.5	10.3	73.2	0.12	clay
B2t	85-133	1.66	37.3	12.1	50.2	0.24	clay
B3t	133-200	1.65	47.1	8.5	44.4	0.16	clay
	PEDON GO5		MID SLOPE				
A	0-18	1.31	47.3	19.6	23.1	0.37	clay loam
AB	18-40	1.6	36.7	13.2	50.1	0.21	clay
B1t	40-95	1.65	23.1	8.4	68.5	0.11	clay
B2t	95-150	1.65	42.9	7.8	49.3	0.14	clay
B3t	150-205	1.66	39.4	14.4	46.2	0.24	clay
	PEDON GO6		VALLEY BOTTOM				
Ap	0-20	1.44	57.5	14.3	28.2	0.34	sandy clay loam
B1g	20-43	1.62	59.0	11.0	30.0	0.37	sandy clay loam
B2gt	43-95	1.68	28.1	16.2	55.7	0.23	clay
B3gt	95-182	1.68	19.9	9.6	70.5	12.0	clay

Appendix 1

Soil Profile Descriptions

PEDON GO4

Location: Arondizogu

Topography: undulating with gentle slope physiographic.

Position: crest

Parent material: Shale

Vegetation/land use: Fallow with mostly trees and broad leaves

Drainage: well drained

Groundwater level: below profit pit

Soil classification: USDA: Typic tropudalf, clayey, mixed isohyperthemic. FAO: orthic luvisol

Soil Profile Description

A (0-16cm): Dark brown (7.5 YR$^4/_2$, dry) clay loam; strong medium sub angular blocky; firm, sticky and slightly plastic, fine and medium pores, many medium and fine roots; diffuse boundary

AB (16-42cm): Dark brown (7.5 YR $^4/_2$, dry) clay; weak medium sub angular blocky; firm, sticky and plastic; medium and fine pores and roots; few charcoal specks: diffuse wavy boundary

B1t (42-85): Yellowish brown(10 YR $^5/_6$, moist) clay, many medium red (2.5 YR $^4/_6$, moist) and dark gray (10YR $^4/_1$, moist) motties, weak fine and medium subangular blocky; firm, sticky and plastic medium and fine pores, few medium and fine horizontal roots ; diffuse wavy boundary.

PEDON GO5

Location: Arondizogu

Topography: Steep slope,

Soil Classification; USDA: Typic tropudalf, clayey mixed isohyperthemic. FAO: orthic luvisol.

Parent material: shape

Vegetation and Land Use: fallow composing of trees and grasss

Soil Profile description

A (0-18cm): Light brownish gray (10 YR $^6/_2$ moist) clay loam; moderate medium sub angular blocky; friable slightly sticky and slightly plastic; medium and fine roots; diffuse wavy boundary.

AB (18-40cm): Dark yellowish brown (10YR $^4/_4$, moist) clay; few fine red (2.5YR $^4/_6$, moist) mottles; moderate medium sub angular blocky; firm, sticky and plastic, common medium and fine roots, medium and fine roots; few angular shaped, dark gray(10YR $^3/_1$, moist) concretions, gradual smooth boundary

B1t (40-95cm): Gray (10YR $^5/_1$, moist) clay medium and fine red (10YR $^4/_6$, moist) mottles, moderate medium sub angular blocky; very fine, very sticky and very plastic, few medium, few fine and very fine pores, few fine roots; common medium and fine irregular shaped iron concretions; clear smooth boundary

PEDON GO6

Location: Arondizogu,

Topography: Gentle slope,

Physiographic position: valley bottom,

Parent material: Shale

Vegetation/land use: Rice farm

Drainage: Imperfectly drained

Soil Classification: USDA: Vertic tropudalf, clayey mixed isohyperthemic,
FAO: Gleyic luvisol

Soil Profile Description

Ap(0-20cm): Gray (10YR $^6/_1$, moist) sandy clay loam: weak medium sub angular blocky; friable, slightly sticky, slightly plastic, few medium, and fine pores, common medium and few fine roots clear wavy boundary.

B1g (20-43): Grayish brown (10YR $^5/_2$, moist) sandy clay loam; yellowish brown (10 YR $^5/_6$, moist) mottles; moderate coarse sub angular blocky; slightly firm, slightly sticky and slightly plastic; few fine and very fine pores, very few medium and few fine roots, diffuse wavy boundary

B2gt (43-95cm): Gray(10 YR, moist) clay; few medium and fine yellowish brown(10 YR $^5/_6$, moist) and few medium and fine red (10 YR $^4/_6$, moist) mottles; strong coarse sub angular blocky; very firm, very sticky and very plastic; very few medium, fine and very fine pores; very fine roots; diffuse wavy boundary.