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PHYSICAL PROPERTIES OF INLAND VALLEY SOILS OF CENTRAL CROSS RIVER STATE, NIGERIA

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ABSTRACT

The physical properties of six Inland valley pedons in central Cross River State, Nigeria were investigated. The percent total sand generally decreased with increase in profile depth with the mean total sand for the surface horizons of 47.4% and 37.2% for the subsoil horizons. The mean of percent silt for the surface horizons was 26.9% and 27.2% was that of the subsoil ones while the corresponding values for clay were 25.9% and 38.7%. The percent clay generally increased with increase in profile depth. The surface layers were generally loamy in texture while the subsoil layers were clayey. The mean bulk density of the topsoil horizons was 1.03gcm^{-3} while that of the subsoil was 1.32gcm^{-3}. Mean particle density of the surface and subsoil horizons were 2.31gcm^{-3} and 2.29gcm^{-3} respectively. The mean of total porosity for the surface horizons was 55.1% and that of the subsoil horizons was 32.18%. Soils with these physical properties are very suitable for swamp rice production and dry season farming since their erodibility is low and capillarity high.

Key words: Physical properties, surface soil, subsoil horizon, porosity, texture.

INTRODUCTION

Inland valley soils possess high agricultural potentials because of their high inherent fertility, highly reduced erosion hazards, availability of water (even during dry season), etc.(Ahmad, 1982)

In agriculture and land use planning, knowledge of soil physical properties is important because they can hardly be changed; and structure, bulk density and texture influence root development (De Kimpe and Mehuys, 1979). The knowledge of a soil's texture can help us approximate its mineralogy, physico-chemical properties and consequently the nutrient status. Texture directly influences infiltration, moisture retention and drainage. Infiltration is highly controlled by bulk density; restricting it where the bulk density is high. Medium or fine textured soils with bulk density values exceeding 1.65gcm^{-3} have low infiltration rates. In such cases root proliferation and penetration is inhibited. Highly productive soils (medium to fine texture) possess bulk density values ranging between 1.0 -1.5gcm^{-3}. Soils of this nature have porosity values ranging from 39-58%(FAO, 1979). Sandy or loamy sand textured soils are usually derived from quartz; and to a lesser extent contain little quantity of feldspar and other minerals. Sandy soils are poor water and nutrient retainers, requiring additional clay and organic fertilizers (Zonn, 1986). On the contrary clayey soils have densely packed structure and retain large quantities of water and nutrients. With respect to texture the B-horizons of most soils posses greater clay percentages corresponding to soil age i.e. increasing in older soils.

Soil high in silt (especially fine silt) have problems of aggregation because of low clay content. Where humus too is low, such soils will have unnoticeable structure and highly susceptible to water and wind erosion.

Brinkman and Blokhuis (1986) reported that inland valley soils have textures ranging from

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clays to sand but the former predominate. Their work also show that, the greatest variation in texture is found in the A-horizon, consequently, the solum would range from sandy clay to clay.

Kosaki and Juo (1982) reported that the inland valleys of central Nigeria and Sierra Leone possessed coarse textures while those of southeastern Nigeria had fine textures.

Zonn (1986), stated that less is known about tropical soils with respect to porosity. Considering the importance of soil-plant relationship, this study aims at discussing the physical properties of inland valley soils of Central Cross River State, Nigeria. for potential agricultural use.

MATERIALS AND METHODS

Environment of study Area:

Six profiles chosen from central Cross Rivers State (latitude 4⁴45' N and 6⁰45' N and longitude 7⁰45' and 9⁰00'E) were dug. Two profiles were dug in each of the following locations; (Fig. 1) Akpet 1 (APT-1 and APT-2); Abini (ABN-3 and ABN-4); and Apiapum (APP-5 and APP-6). These sites constitute areas with extensive inland valleys in central Cross River State.

Geologically, the study area is made up of cretaceous sand-stone and shale of the Eze-Aku group of the South-Eastern Benue Trough (Petters, 1995). The mean annual rainfall of Akpet 1 is about 2500-3000, Abini 2250-2500mm, and Apiapum 2000-2250mm per annum (CRADP,1992). Bush regrowth and crop farm predominate the study area though it is in the lowland rain forest zone. The inland valleys are annually cultivated to swamp rice during the rainy season and sweet potato and vegetables like okra during the dry season.

Preliminary studies were conducted by gathering relevant information on geology, rainfall, and vegetation from existing literatures (Ekwueme, Nyong and Petters, 1995; CRADP,1992) and interviewing of local residents.

Each Profile pit was sited at the centre of the nearly level extensive inland valleys. A total of 25 soil samples were collected from the horizons of the profiles.

LABORATORY STUDIES

Samples brought from the field were air-dried and sieved through a 2.00mm sieve for the following analyses. Particle size analysis was determined by method described by Day (1965). . Sodium hexametaphosphate was used as the dispersant.

The total sand was collected, air-dried and sieved into two sizes, coarse sand (250-2000um) and fine sand (50-250um).

Using the percentage sand, silt and clay results, the texture was determined using the USDA textural triangle (NSSC,1995).

Bulk density was determined by collecting undisturbed core samples from each horizon using (100cm^3) metal rings. These were later oven-dried at 105^{0}C to constant weight and the bulk densities calculated as described by Blake (1965).

Particle density was determined as described by Bowles (1992) using a pycnometer.

The total porosity was mathematically determined from the results of bulk and particle densities (Vomocil,1965).

RESULTS AND DISCUSSION

Results of particle size distribution are shown in table1. The texture of the soils are between loam and clay. The surface horizons were either one form of loam or the other except pedon APT-2. The textures of surface and subsoil horizons varied between sandy clay loam and clay.

The total sand contents of the soils decreased with increase in soil depth except for profile ABN-4 and APP-5 suggestive of fluventic properties. The surface horizons had total sand fraction ranging from 30.4% to 59.8% with an average of 47.4% while the subsoil horizons values range between 8.4% and 60.4% with an average of 37.2%. The percentage fine and coarse sand fractions fluctuated with depth.

The content of silt fraction ranged between 12.0% and 46.0% with a mean of 27.4%. The silt contents of the topsoil horizons were between 19.4% and 36.0% with an average of

TABLE 1 : PARTICLE SIZE DISTRIBUTION AND TEXTURE OF THE SAMPLED SOILS

Profile	Horizon	Depth (cm)	Fine Sand	Coarse Sand	Total Sand	Silt (%)	Clay (%)	Texture
APT-1	Apg	0-28	0.0	29.8	39.8	36.0	24.2	Loam
	BAg	28.45	26.8	7.8	34.6	46.0	20.2	Loam
	2Btg.1	45-75	11.0	18.8	29.8	36.0	34.2	Clay loam
	2Btg2	75-134	11.0	14.8	25.8	34.0	40.2	Clay
	2Btg3	134-183	10.6	17.2	27.8	30.0	42.2	Clay
APT-2	Apg	0.30	10.0	20.4	30.4	19.4	50.2	Clay
	Btg.1	30-62	11.6	0.2	11.8	33.4	54.2	Clay
	2Btg2	62-105	4.6	3.8	8.4	27.4	64.2	Clay
	2Btg3	105-180	1.0	7.4	4.4	23.4	68.2	Clay
ABN-3	Apg	0.10	16.4	43.4	59.8	26.0	14.2	Sandy loam
	BAg	10-40	14.0	25.8	39.8	24.0	36.2	Clay loam
	2Btg1	40-70	20.0	3.8	23.8	28.0	48.2	Clay
	2Btg2	70-140	18.0	11.8	29.8	22.0	48.2	Clay
ABN-4	**Apg**	0-15	15.8	40.0	55.8	30.0	14.2	**Sandy loam**
	Batg.1	15.27	17.2	45.2	62.0	19.4	18.2	**Sandy loam**
	2Btg2	27-43	32.0	28.4	60.4	17.4	22.2	**Sandy clay loam**
	2Btg3	43-152	2.2	54.2	56.4	21.4	32.2	**Sandy clay loam**
APP-5	Apg	0.20	20.0	29.8	49.8	28.0	22.2	Sandy clay loam
	BAg	20-40	30.8	13.8	44.6	24.0	32.2	Clay loam
	2Btg1	40-115	15.6	11.2	26.8	38.0	35.2	Clay loam
	2Btg2	115-115	42.2	15.6	57.8	18.0	24.2	Sandy clay loam
APP-6	Apg	0-25	27.0	21.8	48.8	22.0	30.2	Sandy clay loam
	2Btg.1	25-74	31.0	8.8	39.8	30.0	30.2	Clay loam
	2Btg2	74.112	19.9	20.0	39.8	12.0	48.2	Clay
	2Btg3	112-183	11.2	18.8	30.0	32.8	37.2	Clay loam

Table 2: **BULK DENSITY, PARTICLE DENSITY, POROSITY AND SOME CHEMICAL PROPERTIES OF THE SOILS.**

Profile	Horizon	Depth (cm)	Bulk Density (gcm^{-3})	Particle Density (gcm^{-3})	Porosity (%)	ORG.C (%)	TOTAL N (%)	AVAIL.P (mg/kg)
APT-1	Apg	0-28	1.02	2.24	54.46	3.34	0.17	10.55
	BAg	28-45	1.52	2.10	27.62	1.04	0.08	10.85
	2Btg.1	45-75	1.61	2.36	31.78	1.16	0.06	1.50
	2Btg2	75-134	1.66	2.16	23.15	0.84	0.04	1.05
	2Btg3	134-183	1.69	2.28	25.88	0.72	0.04	1.20
APT-2	Apg	0 - 30	N.D*	N.D	N.D	3.24	0.42	19.45
	Btg.1	30 - 62				1.54	0.18	6.80
	2Btg2	62 -105				0.82	0.06	2.00
	2Btg3	105 -180				1.04	0.06	3.10
ABN-3	Apg	0 - 10	0.88	2.24	60.71	3.33	0.36	3.40
	Bag	10 - 40	1.22	2.40	49.17	1.46	0.15	6.70
	2Btg1	40 - 70	1.41	2.44	42.21	1.02	0.07	1.00
	2Btg2	70 -140	1.44	2.32	37.93	1.00	0.03	1.30
ABN-4	Apg	0 - 15	N.D	N.D	N.D	2.12	0.21	7.25
	Batg.1	15 - 27				0.96	0.10	8.75
	2Btg2	27 - 43				1.12	0.10	8.35
		43 -152				0.72	0.04	2.30
APP-5	Apg	0-20	0.88	2.49	64.66	1.34	0.08	2.35
	BAg	20-40	1.46	2.25	35.11	0.59	0.03	3.50
	2Btg1	40-115	1.46	2.33	37.34	0.20	0.05	2.75
	2Btg2	115-183	1.56	2.19	27.40	0.14	0.03	4.85
APP-6	Apg	0-25	1.35	2.28	40.79	0.88	0.24	13.10
	2Btg.1	25 -74	1.43	2.15	33.49	0.22	0.08	1.50
	2Btg2	74 -112	1.63	2.47	34.01	0.26	0.07	2.05
	2Btg3	112 -183	1.59	2.27	29.96	0.24	0.05	1.85

N D: Not Determined

26.9% while .ne subsoil horizons had values in the range ..0% to 38.0% with an average of 27.2%.

Th clay fractions of the soils increased with incr .se in profile depth except for pedons .P-5 and APP-6. This is an indication of cla' migration by lessivage capable of produ he process of podsolization. Obser atic .r this clay sequence pariparsu the total .nd s.iggest that the soil forming sequence in th se soils may have been from a variety of oric is (Zonn. 1986). The surface horizons had cla fraction ranging between 14.2% and 50.2% with a mean of 25.9% while for the subsoil horizons it ranged between 18.2% and 68.2% with a mean of 38.7%. The range of total clay fraction is from 14.2% and 68.2% to give a mean of 35.6%.

All the soils can be described as heavy textured (the dorminant texture being loam except in APT-2) because of their predominantly clay related textures (Ahn, 1993). This clayey texture of the soil account for the low permeability of these inland valleys.

The results of bulk density are shown in table 2. The results are for four out of the six studied because of lack of standard cores. The results show a common trend of increase in bulk density with increase in soil depth.

The topsoil horizons had bulk density ranging between 0.88gcm^{-3} and 1.38gcm^{-3} with a mean of 1.03gcm^{-3}. The subsoil horizon values ranged between 1.22gcm^{-3} and 1.6gcm^{-3} with a mean of 1.32gcm^{-3}.

The bulk density of the surface horizons are ideal for agronomic practice. This is because topsoil containing a good amount of humus with a crumb structure should have a bulk density of 1.2gcm^{-3} or even lower as in organic soils. For the subsoil, the bulk density would be 1.5-1.6gcm^{-3} or higher in compacted or indurated horizons and the like (Ahn, 1993).

The results of this study are similar to that of Jewitt et al (1979) who stated that the bulk densities of wetland soils vary between 1.0 and 2.0gcm^{-3} and inc..ase with depth. All the sampled soils ha. no problems of excessive high bulk dens..es because bulk densities less than 1.8gcm^{-3} do not impede root penetration. Even more favourable are results of the topsoil horizons that are lower than 1.6gcm^{-3}, since soils with values of 1.6 -1.8gcm^{-3} indicate that aeration and water movement will be too low for optimum root growth (NSSC,1995). Zimmerman and Kardos (1961) stated the bulk densities of most productive (medium to fine textured) soils range from 1.0 – 1.5gcm^{-3} and 1.1 – 1.65gcm^{-3} for coarse textured ones. The values of bulk density for soils in this study perfectly fit in the former range.

The particle density of all the soils were between 2.10gcm^{-3} and 2.49gcm^{-3} with an average of 2.28gcm^{-3} (table2). The surface and subsoil horizons had results ranging from 2.10-2.49gcm^{-3} and 2.15-2.47gcm^{-3} with means of 2.31gcm^{-3} and 2.29gcm^{-3} respectively. These averages are less than the expected average of 2.6gcm^{-3} (Chopra and Kanwar, 1991). Usually, the particle densities of soils is a reflection of the dominant minerals in the soil and rocks. Consequently, the soils studied could have been made up of minerals whose densities fall in these ranges e.g silicate clay minerals (2.00 -2.70gcm^{-3}) and possibly some hydrous oxides of iron and aluminum (2.4 - 4.3gcm^{-3}) (Troeh and Thompson, 1993; NSSC, 1995).

The total porosity of the surface soil ranged from 40.8% and 64.7% with a mean of 55.2% while the values for the subsoil horizons ranged from 23.2% to 42.2% with a mean of 32.2% (Table 2). In general the porosity values decrease with increase in profile depth showing an inverse relationship with bulk density.

The surface soils have good porosity values (with a mean of 55.2%). Kachinkii (1965) suggested that best soils should have porosity of over 50%, good soils between 45-50%, satisfactory soils 40-45%, while unsatisfactory soils under 40% and below 30% for poor soils.

CONCLUSION

These inland valleys are texturally clayey (i.e either sandy clay loam, clay loam or clay) and very suitable for swamp rice production because of their highly mottled horizons and abundant capillary pores (indicative of high water retention)

Following their physiography, soils of this nature will be very suitable for dry season farming. Since the land is gently sloping (0-2%) coupled with their valley bottom position upon irrigation, the probable problems of moisture retention or soil erodibility would be reduced to the minimum.

In addition, cost of irrigation is highly reduced because of absence of ditches and torrent structures. Above all the choice of climatically suitable crops won't constitute a problem since a whole range of tropical crops (cereal, vegetable, root, tuber, etc) already thrive in this agro-ecological zone.

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