MOISTURE RETENTION CHARACTERISTICS OF SOILS OF DIFFERENT LITHOSEQUENCES IN SOUTHEASTERN NIGERIA IN RELATION TO PARTICLE SIZE DISTRIBUTION

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ABSTRACT
Moisture retention characteristics varied among soils within southeastern Nigeria. Soils were derived from Alluvium, Coastal Plain Sands, Shale, Lower Coal Measures, Upper Coal Measures and Falsebedded Sandstones. Geologic map of southeastern Nigeria was used to identify sampling points in the field. Random soil sampling technique was used in locating sampling points. Regression analysis was conducted to establish relationship between soil moisture retention and some soil properties using SAS Computer Software. Soils formed from Lower Coal Measures had highest mean total available water capacity (TAW = 27.40) while those soils derived from Shale had highest soil moisture retention (SMR) of 55.19. The TAW values ranged from 4.03 to 27.40. Least total available water was found in soils over alluvium (4.03). Total available water had a significant relationship with total sand (R^2 = 0.56, P=0.01). Soil moisture retention characteristic dependent variable was highly predicted by independent variables of total sand, clay content and organic carbon at various tension levels of 0.01, 0.05, 0.1 and 1.5 Mpa having R^2 values of 0.86, 0.79, 0.73 and 0.76, respectively

Keywords: Parent materials. Pedogenesis, Soil moisture availability and soil texture

INTRODUCTION
Soil texture is an important factor which influences other soil properties. One of such influenced properties is soil moisture content, which shows the amount of water contained in a unit mass or volume of soil including its energy state. Mbagwu *et al.* (1983) reported that available water can be predicted using moisture contents at different suctions (0.0, 0.1, 0.3 and 15 bars). Lal (1979) obtained a significant correlation field capacity, wilting point moisture content and percent clay content in southwestern Nigeria soils. Fitzpatrick (1990) noted that texture influences hydraulic properties of soils which determine soil moisture retention characteristics. Soil moisture influences soil compressibility (McNabb, 1996), shrinkage (Bronswijk, 1990), tillage and trafficability (Droeger *et al.*, 1996) and root development (Onweremadu *et al.*, 2008). Soil moisture content relate with other soil properties such as bulk density (Imhoff *et al.*, 2004) and soil texture (Harte, 2000) over time (Chertkov *et al.*, 2004) to influence soil behaviour. Knowledge of soil–water content is critical for the determination of local energy and water balance, transport of applied chemicals to plants and groundwater, irrigation management (Seyfried and Murdock, 2004). Determination of soil moisture retention is useful in the evaluation and management of irrigation systems(Souza *et al.*, 2004). Mbagwu *et al.* (1983) studied a wide geographical area of Nigeria doing little sampling in Imo and Abia States known for wide range of soil groups. The major aim of the study was to relate soil moisture characteristics to particle size distribution of soils formed over different parent materials in the study area.

MATERIALS AND METHODS
Study area: Imo and Abia States are found within latitudes $4^0\ 40^1$ and $8^0\ 15^1$ North and longitudes $6^0\ 40^1$ and $8^0\ 15^1$ East (Federal Department of Agricultural Land Resources, 1985). Soils are formed on 6 lithological materials, namely Alluvium, Coastal Plain Sands (Benin formation), Shale (Bende-Ameke formation), Lower Coal Measures (Mamu formation), Upper Coal Measures (Nsukka formation) and Falsebedded Sandstone (Orajaka, 1975). The study site belongs to the rainforest agroecology (Igbozuruike,

1975) in the humid tropical climate (Ofomata, 1975). Farming is practiced by over 80% of the entire population. Location map is shown in Fig 1.

Soil Sampling: A free survey approach was used in locating sampling points. This was guided by geologic map of the study area. In each soil group, 5 surface samples were collected giving a total of 30 soil samples for laboratory studies. Sampled points are shown in Fig 2.

Laboratory analyses: Soil samples were air-dried, sieved using 2-mm sieve, and used for laboratory determinations. Particle size distribution was determined by hydrometer method (Gee and Bauder, 1986). Gravimetric moisture content was measured by a procedure of Seyfried and Murdock (2004), in which disturbed soil samples were soaked for 48 hours to attain saturation while the saturated soil samples were placed in the pressure plate extractor and pressure applied at 0.01, 0.05, 0.1 and 1.5 Mpa suctions until water ceased to drain out. Soil samples were weighed and oven dried at 105^0C overnight. Volumetric moisture content (Θv) was calculated by multiplying values obtained from above heat-treated soil samples by their corresponding bulk densities (Seyfried and Murdock, 2004). Total available water (TAW) was computed as water retained between suction 0.01 and 1.5 Mpa that is Θv 0.01 Mpa – Θv 1.5 Mpa = TAW. Atterberg limits were measured by the procedure of Sowers (1965). Bulk density was determined by clod technique (Blake and Hartge, 1986). Soil organic carbon (SOC) was determined by wet digestion (Nelson and Sommers, 1982).

Statistical analyses: Regression analysis was conducted on the soil data using SAS software (SAS, 2000).

RESULTS AND DISCUSSION

Soil properties: Results of some soil properties are shown in Table 1. Alluvial soils were sandiest among the soil groups (mean = 88% total sand) while least sandiness was recorded in soil formed over Shale (mean 25% total sand). The reverse was experienced in clay content. Highest values of organic carbon were obtained from soils derived from Lower Coal Measures (mean = 2.25) with soils on Falsebedded sandstone indicating least value of organic carbon. Bulk density values varied among soils with highest value recorded on soils derived from Alluvium (1.62 g/cm^3), followed by those on Falsebedded sandstone (1.60 g/cm^3) while lowest value was obtained in shale-derived soils (1.31 g/cm^3). Generally, bulk density value of 1.31 g/cm^3 is preferred as best quality since it allows for greater root development, moisture or oxygen retention. Changes in soil texture could be as a result of differences in parent material in addition to management practices since all the sampled points lie within the same rainforest agroecology. Although soil texture is an inherent property of soils, localized leaching and illuviation, pedogenic processes may have contributed substantially to variation in soil texture. Similar findings had been reported by Akamigbo (1983) who further stated that textural differences were due to pedogenesis and this influenced movement of water in soils. Bulk density increased with percent total sand, suggesting that bulk density is influenced by sand fractions. Both sand and bulk density varied with parent material. At all suction pressures ,soils derived from Shale retained more soil moisture while soils formed over Lower Coal Measures had more total available water. This shows that soil water, though abundant may not be available for plant use. The quantity of total available water decreased in this manner: Lower Coal Measures > Shale > Coastal Plain Sands > Falsebedded Sandstone > Upper Coal Measures > Alluvium.

Generally, the sandier the texture, the lower the total available water content. These moisture characteristics relate to irrigation scheduling and transmission of soil water (Igwe *et al.*, 2002). Earlier, Michael (1985) posited that depth of irrigation should be dependent on available moisture holding capacity of the soil in different layers.

Soil moisture retention characteristics, particle sizes and organic matter of soils: Table 3 shows results of stepwise regression analysis performed at different tensions of soil moisture. Total sand associated well with soil moisture characteristics contributing 56% of available moisture ($R^2 = 0.56$, $p = 0.01$). At 0.1 Mpa, clay, total sand and organic carbon related highly with soil moisture, contributing 86 % of water retained at field capacity (R^2 = 0.86, p = 0.01) while clay and total sand contributed 79 % of water (R^2 – value of 0.79) retained at 0.05 Mpa . These two independent variables also predicted 73% soil moisture retention characteristics at 0.1 Mpa (R^2= 0.73, p = 0.01). Finally, clay and organic carbon were good predictor, contributing 76 % of soil moisture retained at 1.5 Mpa level (R^2 = 0.76 p = 0.01). The above results show that percent total sand, clay and organic carbon are good predictors of soil moisture retention at all suction pressures. Mbagwu *et al.* (1983) suggested the use of soil organic matter (SOM) and soil texture in predicting soil moisture content of some soils of southern Nigerian. Best R^2 value obtained at 0.01 Mpa compared favourably with earlier results of R^2 = 0.84 (Lal, 1979) and R^2 = 0.89 (Igwe *et al.*, 2002) at 1% level of probability. The prediction equations (Table 3) should be subjected to further statistical measures to test for accuracy of prediction and degree of bias. Root mean square error (RMSE) and BIAS statistical tools according to Moldrup *et al.*, (2004) are suggested.

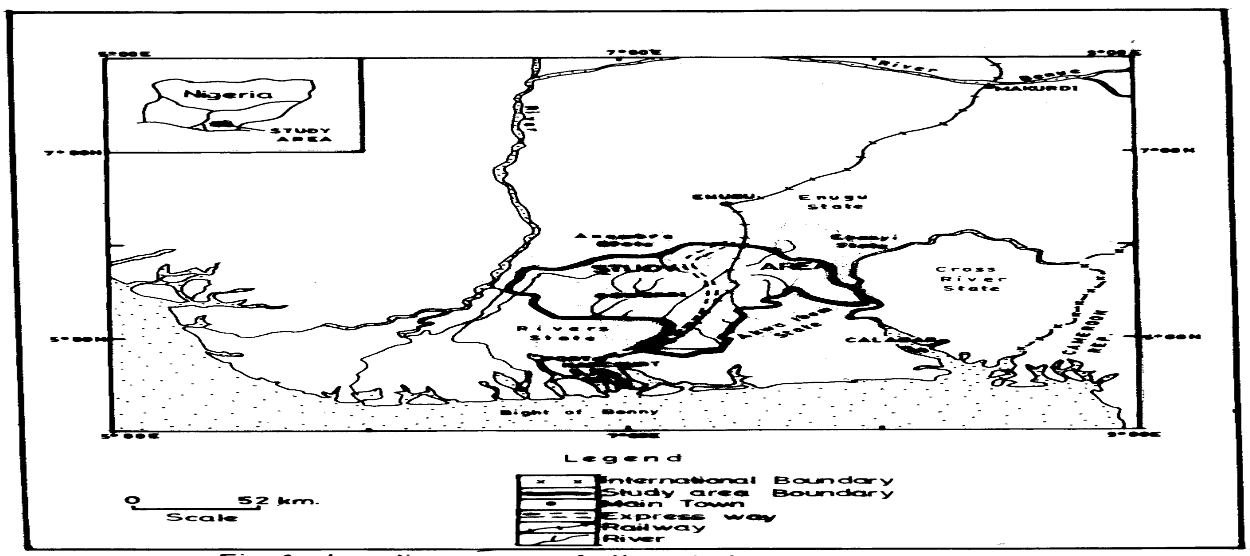

Fig. 1 Location map of the study area

Table 1: Soil properties (mean values)

Origin of soil	Total sa (%)	Silt (%)	Clay (%)	Organic carbon (%)	Liquid Limit (%	Plastic (%) Li	Plasticity index (%)	Bulk dens (g/cm^3)
Alluvium	88	3	9	1.95	18.61	8.21	10.40	1.62
Coastal P Sands	85	2	13	1.86	19.28	7.28	11.90	1.56
Shale	25	15	60	2.01	49.69	4.31	45.38	1.31
Lower C Measures	58	3	39	2.25	25.76	5.19	20.57	1.33
Upper C Measures	85	3	12	1.88	19.08	8.02	11.06	1.48
Falsebedded Sandstone	87	1	12	0.96	19.02	9.26	9.76	1.61

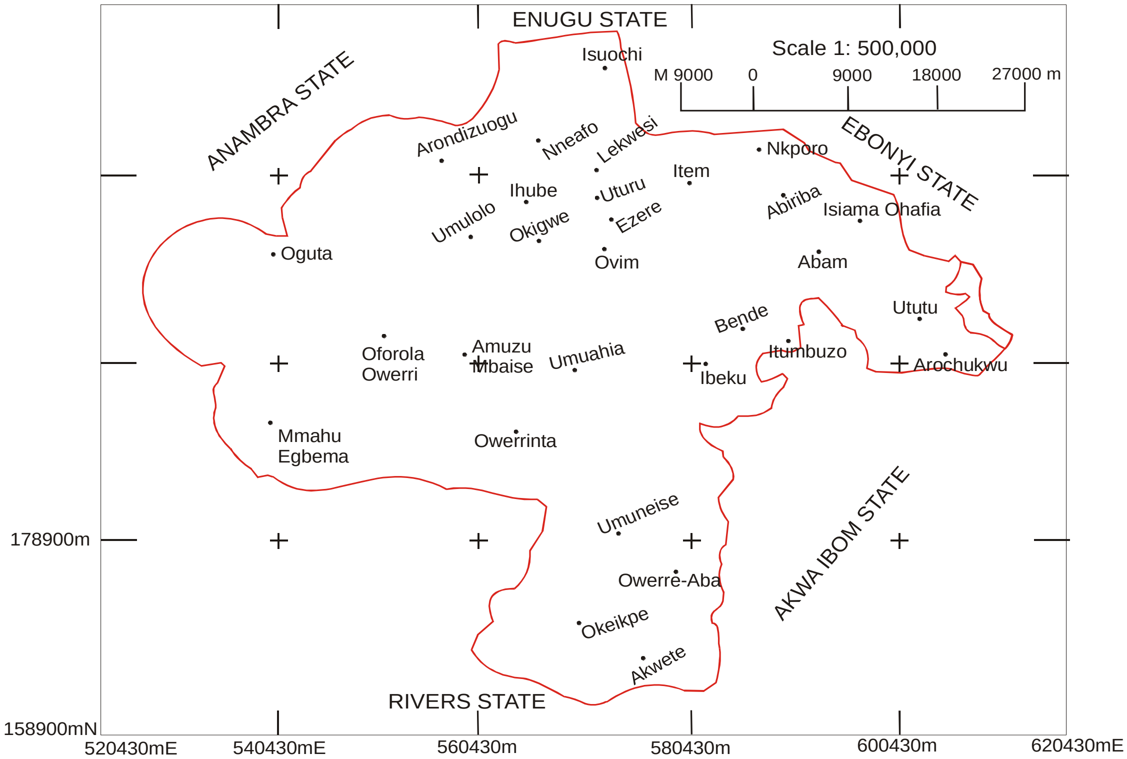

Fig.2: Location map of the study site showing sampled points

Table 2: Volumetric soil moisture retention characteristics (mean values)

	Pressure	(Mpa)			
Origin of soil	0.01	0.05	0.1	1.5	TAW
Alluvium	14.23	11.82	10.92	10.20	4.03
Coastal Plain Sands	25.08	19.56	16.74	12.86	12.22
Shale	55.19	43.83	28.23	29.41	25.78
Lower Coal Measures	37.41	15.03	13.26	8.01	27.40
Upper Coal Measures	22.18	13.58	12.22	11.92	10.26
Falsebedded Sandstones	21.92	13.08	12.21	10.96	10.96

TAW = total available water

Table 3: Regression equations of soil moisture retention characteristics and soil properties

Retention characteristics	Regression model	Coefficient of determination (R
TAW	Y = 35.3 – 9.28 TS	0.56**
0.01Mpa	Y = 33.68 + 0.56 C – 0.38 TS +3.78 OC	0.86**
0.05 Mpa	Y = 28.92 + 0.44 C – 0.28 TS	0.79**
0.1 Mpa	Y = 45.18 – 0.34 TS	0.73**
1.5 Mpa	Y = 2.01 + 0.42 C + 4.21 OC	0.76**

C = Clay, TS = Total sand, CS = Coarse Sand, OC = organic carbon,
TAW = total available water, ** **= Significant at p = 0.01**

CONCLUSION

Particle size distribution and organic matter varied among 6 soil groups. Consequently, there were differences in soil moisture retention due to differences in the determined soil properties. The study showed that soil moisture retained in soil may not be available to crops. Consequently, soils formed over Shale with greatest moisture retention did not have greatest total available water. Finally, a combination of total sand, clay and organic carbon in a multiple regression gave a high predication (86%) of total available water, hence can be used to predict soil moisture retention.

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