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SOIL SPATIAL VARIABILITY OF SOME SOIL PROPERTIES USING FACTOR ANALYSIS IN FEDERAL COLLEGE OF FORESTRY MECHANIZATION, KADUNA RESEARCH FARM

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ABSTRACT
This paper shows the spatial variability of soil properties and factors that contribute to the pattern of variability in Federal College of Forestry Mechanization Research farm. Nine (9) Soil samples were obtained from various points on the farm using random sampling procedure and these samples were subjected to further for laboratory analysis to determine the particle size fraction, soil pH, organic matter content, and from the data obtained was used to determine the Wilting Point (WP), Saturation Capacity (SC), Field Capacity (FC), Available Water Content (AW), Soil Hydraulic Conductivity (SHC), and Bulk density (BD) using SOILWAT software. Descriptive statistics and factor analysis techniques was used to analyze the data obtained, the coefficient of variation ranged from 3.045 to 61.825% and factor analysis showed that the variability of the soil properties is as a result of the textural characteristics, and organic matter.

Keywords: Spatial variability, Soil properties, SOILWAT, Laboratory analysis, Coefficient of variation and Factor analysis.

INTRODUCTION

Soil Characteristics affect its productivity and its pattern of productivity is influenced by the variation in some of the soil properties which can be physical or chemical. Erosion activities on soil brings about variation of soil properties thereby making it necessary to determine the variation of the properties of the soil so that knowledge of where soil amendment or nutrient is needed is obtained. Some researcher had also studied variability in soil properties, like Akpokodje *et al*., 1986; Nwajide and Hogue, 1979; Hu *et al*., 2008; She and Shao, 2009; Ofomata, 1988, and Olorunlana, 2014. Descriptive statistics (mean, standard deviation, range and coefficient of variation) is one of the commonest methods used in examining soil variability and also Adebayo, (1999) introduced factor analysis technique as one of the statistical techniques that reveal factors that affects soil properties variability. The factor analysis helps ascertain the reason for variability and from this statistical technique the factors with Eigen values greater than unity were retained as suggest by a study from Kaiser, (1974) for further principal component analysis. Spatial properties of Soil Properties help in characterizing and acquiring assessable data for detecting and monitoring variability of soil properties and these data would provide further knowledge for crop design, management strategies and precision farming.

METHODOLOGY

Study area

The study was carried out at the experimental farm of the Federal College of Forestry Mechanization (FCFM), Afaka, Kaduna, Nigeria, located at latitude 100 37′ N and longitude 70 47′ E, and situated in the Northern guinea savannah ecological zone of Nigeria. All agricultural related research was carried out on this farm.

Experimental procedure

Undisturbed and disturbed soil samples were obtained from the farm using soil auger and core samplers. Nine (9) samples was taken from the area of research for analysis. The sampling was done randomly in other to cover evenly the study area. The soil samples were air-dried and crushed and sieved using a 2mm sized sieve for particle size analysis. The samples soil PH and Organic Carbon was determined in the laboratory. Organic Carbon data obtained was multiply by a conversion factor to obtain the soil organic matter. Organic matter and soil textural characteristics data was used as an input for the SOILWAT model software so as to obtain the other properties used in this research (the Wilting Point (WP), Saturation Capacity (SC), Field Capacity (FC), Available Water Content (AW), Soil Hydraulic Conductivity (SHC), and Bulk density (BD)).

Statistical analysis

Descriptive Statistics was used to analyze the soil properties. The mean shows the average distribution of the variables, standard deviation shows how the variable deviates from the mean and the coefficient of variation was used to show the percentage of variation of the soil properties. Factor analysis technique was used to group the soil properties into eight statistical factors and principal component analysis was used for these factors extraction. Factor (principal component) analysis was executed on standardized variables using correlation matrix (Table 2) in order to eradicate the consequence of different measurement units on the determination of factor loadings. Eigenvalues show the amount of variance explained by each factor. Factors with eigenvalues > 1 explained more total variation in the data than individual soil properties, and factors with eigenvalues < 1

explained less total variation than individual soil properties. Therefore, only factors with eigenvalues > 1 were retained for interpretation.

RESULTS

Variation of soil properties

The variation of soil properties was determined and there was a spatial variation of the soil properties shown through high coefficient of variation as shown in Table 1. The Organic matter shows the highest variation 61.8% and this variation can be as a result of erosion activities and also the various cropping pattern on the farm. The other properties variation can be attributed to the soil textural characteristics which also can be as a result of deposition processes. Recent research shows variability in soil properties resulting in high coefficient of variation in chemical properties, textural characteristics and organic matter, Olorunlana, (2014). Following the procedure from Aweto, (1982) the result from the coefficient of variation was further categorized into four classes for further analysis. From Table 1, less than 20% CV is regarded as low variability; between 21 and 50% CV is regarded as moderate variability while between 51 and 100%. WP and SHC shows high CV (52.948 and 48.062%) which implies the relative moisture content retention ability of the various portion of the farm. The Bulk density (BD) exhibited the lowest level of variation of 3.045% indicating that no much variation regarding this properties of the soil.

Table 1: The Descriptive statistics of the Soil properties of FCFM Research Farm

Soil Properties	Mean	Standard deviation	Coefficient of Variation (CV) (%)
Clay	3.721	0.666	17.895
Silt	22.267	7.261	32.610
Sand	74.496	7.746	10.398
OM	4.636	2.866	61.825
PH	7.081	0.600	8.478
WP	7.807	4.133	52.948
FC	16.833	3.715	22.070
SC	45.067	1.431	3.175
AW	2.721	0.114	4.199
SHC	6.787	3.262	48.062
BD	41.087	1.251	3.045

Table 2. Correlation matrix for the soil sample

Variables	Clay	Silt	Sand	OM	PH	WP	FC	SC	AW	SHC	BD
Clay	**1**										
Silt	0.3132	**1**									
Sand	-0.2480	**-0.9562**	**1**								
OM	**0.9400**	0.6117	-0.5490	**1**							
PH	**0.7847**	0.2832	-0.3381	**0.7466**	**1**						
WP	0.6096	**0.7196**	-0.5897	**0.7563**	0.4897	**1**					
FC	0.5994	**0.7484**	-0.6112	**0.7580**	0.4459	**0.9971**	**1**				
SC	0.0945	-0.5049	**0.7034**	-0.1094	-0.0905	0.0946	0.0704	**1**			
AW	-0.1229	-0.5792	**0.7594**	-0.3175	-0.2456	-0.0452	-0.0684	**0.9754**	**1**		
SHC	0.0650	-0.5153	**0.7124**	-0.1379	-0.1133	0.0773	0.0533	**0.9996**	**0.9815**	**1**	
BD	0.5956	**0.8137**	**-0.6936**	**0.7722**	0.5328	**0.9769**	**0.9771**	-0.0244	-0.1587	-0.0414	**1**

Table 3. Eigenvalue and the variability for the soil properties

Factors	Eigenvalue	Variability (%)	Cumulative %
F1	6.0103	54.6387	54.6387
F2	3.3632	30.5745	85.2132
F3	1.2547	11.4064	96.6196
F4	0.2706	2.4602	99.0798
F5	0.0875	0.7953	99.8751
F6	0.0122	0.1112	99.9863
F7	0.0013	0.0122	99.9985
F8	0.0002	0.0015	100.0000

Factor analysis of the soil properties

Correlation matrix was generated for the soil properties as shown in Table 2, and this was done before the factor analysis procedure was carried out. The factor analysis method helps to understand the type and range of relationships between the soil properties. The Eigen value structure of the soil properties are shown in Table 3. The factors with Eigen values greater than unity were retained. According to this, all the four factors in the table with highest percentage (%) were retained, explaining the total variance in the sample. To acquire a perfect and steady form of variation, these four factors extracted were rotated using a Varimax method. The figure 1 shows the Scree plot for the eigenvalue and the cumulative variability for the soil property. The rotated factor shows clearly the role of the different soil properties in soil spatial variability and Table 4 shows the loadings on each of the rotated factors and the first factor exhibited high negative loading on sand and high positive loading on silt, clay and organic matter reflecting factor reflects textural characteristics. The second factor shows a low negative loading on silt and also exhibit high positive loading on SC, SHC, and AW, reflecting textural characteristics**.** The third factor shows a moderate loading on Clay, and PH, reflecting textural characteristics and Chemical properties while The fourth factor exhibit extremely low positive and negative loading on the soil properties.

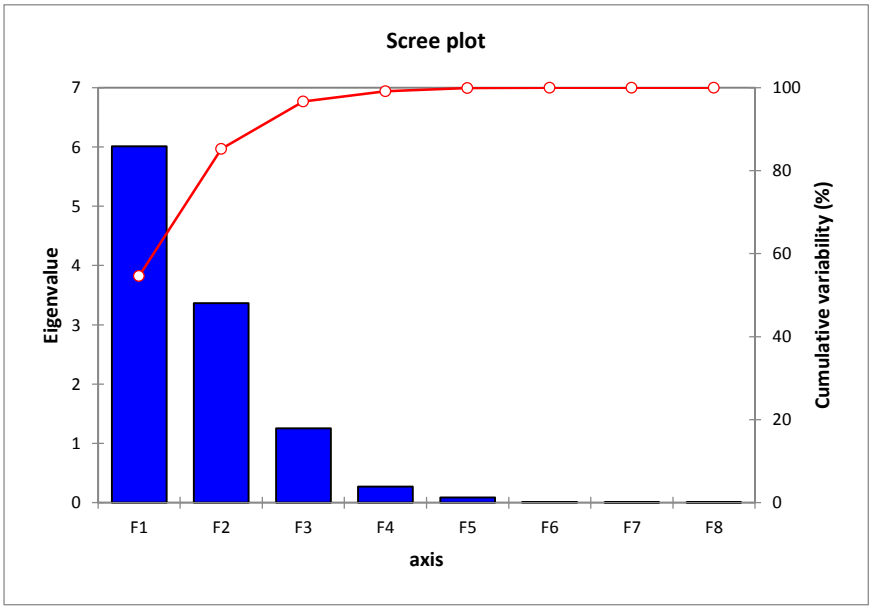

Figure1. Scree plot for the eigenvalue and the cumulative variability for the soil property

Table 4. Component matrix for the factor plots

	Components			
Soil Properties	1	2	3	4
Clay	0.6731	0.4441	0.5448	-0.2283
Silt	0.8878	-0.2166	-0.3624	-0.0379
Sand	-0.8644	0.4263	0.2337	-0.0700
OM	0.8726	0.2816	0.3288	-0.2167
PH	0.6400	0.2358	0.6197	0.3870
WP	0.8402	0.4495	-0.2676	0.0404
FC	0.8474	0.4220	-0.2984	-0.0193
SC	-0.3935	0.9130	-0.0863	-0.0060
AW	-0.5422	0.8127	-0.1905	0.0665
SHC	-0.4141	0.9022	-0.1029	0.0024
BD	0.8980	0.3380	-0.2546	0.0948

CONCLUSION

The spatial variability of some soil properties was carried out and result shows high coefficient of variation values and these can be deduced from the variations is as a result of various soil use and other related activities. Also, textural characteristics differences as a result of erosion activities aids the variation because these cause the redistribution of soil particles from one location to the other. Moreover, the spatial variability of the soil properties on this farm seems to be mainly from the organic matter, and textural characteristics. These two properties are then needed to be taken into account as a tool needed for further knowledge for crop design, management strategies and precision farming.

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