ANALYSIS OF PHYSICO-CHEMICAL AND HYDRUALIC CHARACTERISTICS OF SOIL IN FOREST AREA OF SOUTHWESTERN, NIGERIA

ABSTRACT

In this area of agricultural transformation by the government of Nigeria, every opportunity in order to achieve food security should not be ignored. Most studies on soil characteristics had centered on the suitability of the soil for agricultural production and it is observed that any soil that does not support crop production refers to as poor and unproductive. Achieving efficient production and high yield requires adequate knowledge of the soil and climatic conditions that are favorable to the crops. The study was conducted to investigates physico-chemical and hydraulic properties of forest soils in southwestern, Nigeria in latitude $7^{o}\,5^{'}\,3^{''}$N and $7^{o}\,21^{'}\,57.6^{'}$N and longitude $5^{o}\,10^{'}\,31^{''}$E and $5^{o}\,56^{'}\,6.3^{''}$E. The soil samples were randomly taken from four (4) forest locations in Ondo State, Nigeria. The soils were taken at different depths (0-15 cm, 15-30 cm, and 30-45 cm) and the samples were taken to the laboratory in order to determine their pH, electrical conductivity, exchangeable cations, and texture. The results of the soil test were then subjected to appropriate statistical analyses. Results show that sandy soil had the highest percentage in the forest at kajola oju-irin (70%). The bulk density is high in Ijare with 1.6g/cm^3 which could allow easy penetration of water and nutrient. Also, the soil pH, electrical conductivity and exchangeable cations range from 4.65 to 6.99, 78.28 to 89.20 mS/cm and 0.40cmol/kg to 2.60 cmol/kg respectively. The soils are described as light and falls under sandy loam soil. This study provides information on the suitability of the soils in the forest areas in south west Nigeria.

1.0 INTRODUCTION

Soil is a critically important resource, the efficient management of which is vital for economic growth and development for the production of food, fiber and other necessities. Soils are made up of four basic components: minerals, air, water, and organic matter. In most soils, minerals represent around 45% of the total volume, water and air about 25% each, and from 2% to 5% organic matter (Rezaei, *et al.,* 2008). Soil nevertheless is fundamental to ecosystem and agricultural sustainability and production because it supplies many of the essential requirements for plant growth like water, nutrients, anchorage, oxygen for roots, and moderate temperature and it also serves a vital function in nature, providing nutrients for plant to grow as well as habitat for millions of micro- and macro-organisms (Brant, *et. al.,* 2006). The ability of a soil to support plant growth depends on its physical and biological properties which have been found to play significant roles in crop production and also the physical condition of soil affects the ability of plants roots to acquire nutrients from the soil. Healthy soil enables vegetation to flourish, releases oxygen, holds water and diminishes destructive storm runoff, breaks down waste materials, binds and breaks down pollutants, and serves as the first course in the larger food chain (Eni *et al.,* 2011). According to Warncke (2007), a fertile soil is more than just having adequate levels of the essential nutrients, for plants to take up adequate amounts of nutrients the soil must have good tilth or structure. The structure of the soil is developed through the action of soil microorganism especially fauna creates openings for water and air penetration and secretes glues and sugars which bind silt and clay particles together to form aggregates (Micheal, 2009). Microorganisms help open up compacted soils so roots can more easily penetrate the soil. Soil structure affects aeration, water movement, conduction of heat, resistance to erosion and plant root growth. Water has the most substantial effect on soil structure due to its solution and precipitation of minerals and its effect on plant growth (Unanaonwi *et al.,* 2013). Forest soils are generally subjected to fewer disturbances than agricultural soils, particularly those that are tilled, so forests soil tends to have better preserved A-horizons than agricultural soils. Disturbance to forest soils tend to be related to fine and timber harvesting. Land use change, wildfire, drainage, timber harvest, nitrogen deposition, and site preparation can greatly affect soil characteristics, which in turn will affect forest productivity and health, including quality and quantity of water. The longer cultivation period and shortened fallow duration under ever-increasing demographic pressure have been threatening the productivity and sustainability of the forest area in Africa (Watanabe *et. al.,* 2015). The need for maximizing the use of available land resources with high yield tree species had become desirable and achieving this goal greatly depends on climate and soil conditions (Ravindranath *et al*., 2006). Inherent soil productivity of the farmland is one of the significant farm variables and is directly related to soil properties. Understanding the soil of the farm, therefore a very crucial aspect of any crop production prospect and lumbering planning. Soil characteristics are made up of two properties namely physical and chemical, and soil will usually behave according to the proportion and organization of these properties.

1.1 Physico-chemical properties of soil

Physical properties of forest soils develop under natural conditions by the influence of permanent vegetation over a long period. The physical properties of soils affect every aspect of soil fertility and productivity. The physical properties of soils, in order of decreasing importance, are texture, structure, density, porosity, consistency, temperature, color and resistivity. These determine the ease of root penetration, the availability of water and ease of water absorption by plants (Chinevu *et al*., 2013). Clays are quite different from sand or silt, and most types of clay contain appreciable amounts of plant nutrients. Sandy soils are less productive than silts, while soils containing clay are the most productive and use fertilizers most effectively (Milford,2001).Chemical properties of soils are important and it helps in determines the availability of nutrients and regulates the supplies of nutrients to the plant, the health of microbial populations and its physical properties. It also determines its corrosivity, stability and ability to absorb pollutants and to filter water. The chemical properties of soil include soil pH, electrical conductivity and exchangeable cations. Soils are made up of some elements which are the nutrient for plant growth and these elements are divided into macro and micro nutrients. The macro elements are required in large amounts by plants for optimum growth and micro nutrients are required in small quantity. In the reaction to the growth and yield of the plant, soil pH is a power house for the plant nutrients (Unanaonw, 2011). The ability for the crops to utilize water effectively and take sufficient quantities of nutrients is depending on the level of acidity and alkality of the soil. Cation-exchange capacity (CEC) is the amount of exchangeable cations per unit weight of dry soil and is expressed in terms of milliequivalents of hydrogen ion per 100 grams of soil (NSW-HSCE, 2009). A good knowledge of the variations of soil physical - chemical properties as it relates to micronutrient status is essential for good land evaluation which is a pre-requisite for sound land use planning (Watanabe *et. al.,* 2015). Moreover, information on the profile distribution of these elements in arable crop growing soils will provide the basis for making an informed decision with respect to fertilization and other soil management practices. The cultivation of crops in forest area could still be considered very low in southwestern Nigeria due to the fact many farmers do not have access to cultivable soils with required physico-chemical and hydraulic properties. This study aims at determining the physico-chemical and hydraulic properties of soil in the forest area of southwestern Nigeria so that it provide information on the suitability of the soils for cultivation or required amendments in order to ensure optimum crop yield and better return on the farmers' investment.

MATERIALS AND METHODS

2.1 Study Area

The forest area used for study lies between latitude 7º 5' 3"N and 7º 21' 57.6'N and longitude 5º 10' 31"E and 5º 56' 6.3"N .The forests are located at the north, north-west and southern part of Akure which is the capital city of Ondo State. The cities where the forests are located are Ijare (Ifedore LG), Iwaro-Oka (Akoko South LG), Ala (Akure South LG) and Kajola Oju-Irin (Odigbo LG). The cities have evenly distributed rainfall and moderate temperature. They are thick forest, hilly and rocky area. The soils in the area are mainly Alfisols (*Haplustalf*) derived from the pre-Cambrian basement complex rocks of the Savannah region of Nigeria (Ali *et al.,* 2018)

2.2 Soil Sampling and identification

Soil samples were collected at four different locations in Ondo State, Southwestern Nigeria. The locations are: Ijare (Ifedore LG), Iwaro-Oka (Akoko South LG), Ala (Akure South LG) and Kajola Oju-Irin (Odigbo LG) of Ondo State respectively. The soil samples were collected at the 5cm radius to a soil profile (depth) of 0-15, 15-30, 30-45 cm respectively in each location with the aid of soil core. Samples (1kg each) were taken in plastics bags to the laboratory and air dried for studies. The samples collected were taken to the laboratory at the soil and land resources department of Obafemi Awolowo University to determine their moisture content, pH, electrical conductivity, exchangeable cations and texture. The results of the soil test were then subjected to appropriate statistical analyses. The soil sample were identify with location, Local Government Area (L.G.A) and notation as shown in Table 1

Table 1: Soil Sample Identification and Local Government Area

Sample	Location	L.G.A	Notation
1	Ijare	Ifedore	IJ
2	Iwaro-Oka	Akoko-South	IW
3	Ala	Akure-South	AL
4	Kajola Oju-Irin	Odigbo	KA

3.0 RESULT AND DISCUSSION

3.1 Soil Particle size and Water Retention Analysis

According to Chinevu *et al.* (2013), it has been proved that the physical properties of soil play an essential role in the fertility of the soil because the amount and sizes of soil particles determine the porosity and bulk density which account for nutrients retention or leaching of nutrients. The results as shown in Table 1, indicate the particle size, bulk density, and water retention properties at different depth of the soil. The soil at Kajola oju-irin has highest percentage composition (70%)for sandy and soil in the forest area of Ijare has lowest percentage composition (10%) for clay particles. This size distribution influences the water retention properties of the soil. The porosity of the sandy soil is expected to be highest because sand is the most porous of the soil particles that is the sand cannot retain water. Clay expected to have the lowest percentage composition of porosity that is it has the highest water retain capacity. As shown in the result, the soil in forest area of Ijare will hold more nutrient cations for plant uptake than any other soil in another forest area. This implies the more the clay content of a soil, the higher the cation exchange capacity and the higher the fertility of the soil. The high bulk density is an indicator of low porosity and soil compaction. High bulk density could be as a result of compaction caused by a tractor passes because the farms with high densities were those pulverized by tractor. This conforms to the findings of Abu-Hamdeh (2003) who reported that soil bulk density increased significantly with an increase in compaction depending on the number of passes of tractor wheel.

Table 2: Laboratory Analysis of Physical properties of soil samples at different locations

Location	Soil depth (cm)	Sand (%)	Silt (%)	Clay (%)	Bulk density (g/cm^3)	Porosity (%)	Soil Type
AL	0-15	67	21	12	1.70	34.8	
	15-30	68	21	14	1.68	35.0	Sandy loam
	30-45	65	20	12	1.69	34.4	
IW	0-15	61	16	23	1.74	35.7	
	15-30	62	14	22	1.67	35.9	Sandy clay loam
	30-45	60	12	22	1.72	35.0	
KA	0-15	70	08	22	1.66	37.7	
	15-30	69	10	20	1.64	36.7	Sandy clay loam
	30-45	68	11	21	1.63	36.2	
IJ	0-15	69	20	11	1.73	33.3	
	15-30	69	19	11	1.76	34.3	Sandy loam
	30-45	68	21	10	1.74	35.1	

3.2 Soil pH and Electrical Conductivity

The pH of the soil samples collected at the different forest locations ranged from 4.65 to 6.99 as shown in Table 3. At each forest locations, the soil samples were taken from a different depth. Table 3 shows that the pH value for the four (4) locations at the forest ranged between 4.65 to 6.99. A soil pH of 6.0 to 7.0 is ideal for good plant growth (Haby, 2011). EHS (2014) stated that the preferred pH for almost all vegetables is between 5.5 and 6.5. Therefore, the soil samples are suitable for crop growths and also can support vegetable production. This implies that the soil in the forest locations will be good for vegetable crop productions. The statistical analysis indicated that the soil pH at different locations varies significantly ($P<0.05$). The results of the electrical conductivity of soils in the forest locations ranged from 78.28 to 89.20 mS/cm (Table 3). The lowest electrical conductivity is 78.28mS/cm at forest location in Ijare while the highest electrical conductivity is 89.20mS/cm at 15-30 cm at forest location in Kajola Oju-Irin. The electrical conductivity of the soils in all forest locations was not significantly different ($P>0.05$). The results of the analysis indicated that the soils had very high salinity value. According to FAO standard on salinity tolerance, any value higher than 16 mS/cm is considered high salinity. Based on this threshold value, the high salinity is not appropriate for crop growth in all forest location where the soil sample is been taken. In other to get maximum yield in this forest locations, there is the need to reduce the soil's salinity.

3.2 Exchangeable cations

The plant requires several essential nutrients elements for growth and development. The amounts of some of these elements are shown in Table 3. The exchangeable Na^+ content in the soil samples at forest locations ranged from 0.05 to 0.16cmol/kg as shown in Table 3. Sodium is a micronutrient that aids in metabolism, specifically in the regeneration of phosphoenolpyruvate and synthesis of chlorophyll and excess sodium in the soil limits the uptake of water due to decreased water potential, which may result in wilting (Zhu, 2001). Magnesium acts as a phosphorus carrier in plants and it is necessary for cell division and protein formation. The exchangeable Mg^{2+}in, the soil samples from the forest locations range from 0.40 to 1.10 cmol/kg. The exchangeable Ca^{2+} content in the soil samples ranged from 0.29 to 2.60cmol/kg. Calcium is essential in plant growth because the soil colloid has an excellent saturation of calcium for plant uptake. Calcium accounted for about 2% of plant tissue. The exchangeable K^+ of the soil samples range from 0.09 to 0.26cmol/kg. Potassium is essential in the translocation of vital sugar in plants structure and strengthening plant stalks. The availability of potassium depends upon its position within the soil and relationship to clay, humus and soil water. Soil nitrogen in the study forest location range from 0.05 to 016cmol/kg. The present nitrogen recommendations in most growing situations are based upon experience and are usually more than specific plant requirements. The result on Table 3 shows that the phosphorus in the soil samples at forest locations range from 6.10 to 14.75cmol/kg. Lack of phosphorus in the soil will make the plant to produce red and purple leaf colors and exhibit stunted root and top growth. The desirable concentrations of the main exchangeable cations influencing plant growth according to (Hollaway, 2007) are Calcium (>1.5), Magnesium (>0.4), Potassium (>0.25) and Sodium (as close as possible to 0.0). From the results of the analysis, it shows that Na^+, Mg^{2+} and K^+ at the depths are considerably tolerable expect Ca^{2+} in a forest area in Ala, Iwara-oka and Ijare with value less than the critical value.

Table 3: Variation of chemical properties at Forest locations

Location	pH	EC (mS/cm)	*Na^+ (cmol/kg)*	*Ca^{2+} (cmol/kg)*	*K^+ (cmol/kg)*	*Mg^{2+} (cmol/kg)*	N (%)	P (mg/kg)
AL	6.14^a	86.38^a	0.08^b	1.20^a	0.11^a	0.80^a	0.08^a	6.10^a
IW	6.25^{ba}	80.85^a	0.08^a	1.10^a	0.14^a	0.90^a	0.08^a	4.95^{bs}
KA	6.99^b	89.20^a	0.16^a	2.60^a	0.26^a	1.10^a	0.16^a	14.75^a
IJ	4.65^a	78.28^a	0.05^a	0.90^a	0.09^a	0.40^a	0.0	10.86^a

							5^{a}	

*Means with the same letter are not significantly different (P < 0.05)

Conclusion

The assessment of physico-chemical and hydraulic properties of the soil in the forest location where the soil samples are taken at this moment provide information on the suitability of the soils in the locations as well as other similar soils in Nigeria for the crops cultivation as well as potential amendments. The investigation has shown that the essential nutrients element that needed by the plants are present in the soil samples from the forest locations. The investigation also review that the percentage of sand is high in most of the soil sample in the forest location and the bulk density is high which will make water to easily penetrate the soil. Soils in the forest location are good for the cultivation of crops because properties of the soils meet the requirement of crops growth. Amendment options should also be researched into in order to allow better production in areas that are less suitable for the cultivation of the crops.

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