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Research Article

Assessment of Soil Fertility Status of Some Agricultural Land Use Types in Ayetoro-Gbede Ijumu Local Government Area of Kogi State, Nigeria

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Abstract: This research was carried out to assess soil fertility status of some land use types in Ayetoro-Gbede Ijumu Local Government area (LGA) of Kogi State. Four (4) different land use types were examined, coffee, cocoa, cashew and cassava plantation/farm respectively. Samples were collected at 5 different points and at 2 depths (0-15cm and 15-30cm) on each of the land use types and were mixed homogenously to have 2 soil samples per land use type representing each of the depth. The samples were subjected to physical and chemical analysis. The result showed that the textural class of all the land use types are Loamy sand at both depths except for C1a (coffee) at the top soil with sand textural class. Soil pH at both depths are slightly acidic for all the land use types except C3a (cashew plantation) which is acidic with a pH value of 4.20 and C1b (coffee plantation) which is slightly basic with the value 7.15. The values of soil electrical conductivity (EC), available P, soil organic matter, total nitrogen and potassium (K) at both top and sub-soils are generally low. Effective cation exchange capacity (ECEC) of the experimental area at 0-15cm depth has the highest value at coffee land us. The values recorded for calcium and magnesium in all the land use types is above the critical value. The Na concentration is high when compared with the standard given. For sustainable crop production, cashew plantation will require liming. Soil management which includes crop rotation, planting of cover crop should be embarked upon and application of gypsum/flushing to reduce salinity should be carried out on all the land use types.

Keywords: Fertility Status, Exchangeable Cation, Aiyetoro-gbede, Ijumu, Liming, critical value.

1. INTRODUCTION

According to FAO (2002), Soil is defined as comprising particles of weathered parent rock and a variety of living and dead organic matter from different origin. It is the unconsolidated mineral or organic matter on the surface of the earth; it is a surface that has been subjected to and shows effects of genetic and environmental factors of; climate (including water and temperature effects), macro- and microorganisms, condition by relief, acting on parent material over a period of time. Tiessen, (1994); reported that soils cover a major portion of the earth's land surface. It is an important natural resource that either directly supports most of the plant life. Plants are rooted in soil and obtain needed nutrients there. Animals get their nutrients from plants or from other animals that eat plants. Many animals make their homes or sheltered in the soil. Microbes in the soil cause the breakdown and decay of dead organisms, a process that in turn adds more nutrients to the soil. Soil is a mixture of minerals, organic materials, air and water. The contents of soil vary at different locations and are constantly changing. There are many different kinds and types of soils; each has certain characteristics including a specific colour and composition. Different kinds of soil support the growth of different types of plants and also determine how well that plant grows. Therefore, soil conservation is important for continued support of life (Turrion *et al*., 2000). Minerals in the soil are obtained from a variety of sources, but the process which delivers the bulk is weathering of rocks. Weathering is the action of wind, rain, ice, sunlight, and biological process on rocks that breakdown into smaller particles. Hertly, (1988), investigated that weathering also releases ions such as K and Mg into the soil. Some of these ions are taken up by plants. However, if acid is introduced into soil, hydrogen ions' bonding in preference to clays is formed forcing (Ca^{2+}, Mg^{2+}) ions out where they can be washed

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away during rain. Acidity also encourages the weathering of clays, releasing toxic aluminum ions (of which clays are composed) into the solution. To stop this occurrence, farmers apply alkaline materials such as slaked lime (Tiessen *et al.*, 1994).

According to Vink, (1975), land use is any permanent or cyclic human interactions to satisfy human needs from complex natural and artificial resources which constitute land. It is a resultant interplay of available land resources with cultural, social and economic conditions of the past and present development when two or more land use types occur on the same soil (Akanmigbo and Asadu 2001). Land use has been categorized into major kind; as rain fed agriculture, fishpond, forestry, grazing and tourism and into primary or compound kinds in which more than one kind of land use is practiced within an area (FAO, 2002). Land uses affect soil fertility and productivity. These manifests as change in soil properties such as nutrient content (N, P, K Ca Mg, and S etc.), pH, organic matter, CEC, structure etc. (Aluko and Fagbenro 2000, Akinrinde and Obigbesan 2000, Akamigbo and Asadu 2001). For instance Aluko and Fagbenro (2000) observed increase pH and organic matter for soil under *Gmelina aborea* (teak) than those under *Pins canaborea*, *Treculia Africana*, agro forestry and fallow land. They also observed increased phosphorus in fallow compared to other land uses (Akanmigbo and Asadu 2001). Agricultural sustainability requires a periodic evaluation of soil fertility status, this is important in understanding factors which impose serious constrains to increased crop production under land use types and adoption of suitable land management practices. Information so generated could also be useful in adjusting present land use types or in the development of appropriate land use policy for a given area.

Nigeria, having the largest population of any African country, rapid population growth, a high degree of dependence on agriculture at the household level and large area of low potential (sub-humid and sub-arid) rain-fed farm land, is experiencing predominantly nutrient depletion scenarios (Mortimore and Harris, 2003). Land resource is gradually becoming scarce as increase in population places pressure on natural resources. As world population grows, an increase of food supply is urgently needed to meet those demands.

Presently, in the western part of Kogi State, there is inadequate information on the fertility status and type of soil. Further increase in population has resulted in competition for land among various users without due consideration for the quality of the soil in the area to ascertain whether they are Suitable or not suitable for agricultural use they are considering.

2. MATERIAL AND METHODS

2.1 The Study Area:

The study area is located in Ijumu Local Government Area of Kogi State, Nigeria. The climate of the study area is humid tropical with two distinct seasons (wet and dry seasons) the wet seasons usually starts late march/early April with the pick in July and stops around September with a break in August, and dry season begins from late September to April of the following year. Total annual rain fall ranges between 804.7mm – 1767.1mm (Audu, 2012). The mean annual temperature of Kogi State is about 27.7^{o}C as recorded by (Audu, 2001).

Table .1 Land use types considered for this research in Ayetoro Gbede Ijumu L.G.A of Kogi State

Sample No.	Land use type
C_1	Coffee
C_2	Cocoa
C_3	Cashew
C_4	Cassava

C_1= Coffee, C_2= Cocoa, C_3= Cashew, C_4= Cassava

2.2 Soil Sampling

Samples were taken from four (4) different land use types at two depths of 0-15 and 15-30cm to have eight (8) samples all together. Composite samples were taken from 5 sampling points for each of the land use types. The samples collected were air-dried at room temperature gently crushed to reduce heterogeneity and passed through a 2mm sieve and materials larger than 2mm diameter were removed. Composite sample from each location was labeled and stored in polythene bag for laboratory analysis.

2.3 Laboratory Analysis:

The prepared soil samples were subjected to the following analysis, Particle size Determined by Bouyocous hygrometer method (Bouyocous1962); Soil pH Determination pH electron (McLean, 1982); the electrical conductivity of the soil solution was determined by EC electron (Rayment and Lyons, 2011). the textural classes of the soils were also determined using the textural triangle.

Organic matter was measured using wet dichromate acid oxidation method (Nelson and Somers, 1982).

The Percentages Organic Carbon Was Then Calculated Thus:

% organic carbon= (B-T) x M x 0.003 x 1.33 x 100/wt

Where B = Blank value

T = Sample titre value

M = Molarity of $(NH_4)_2$ $FeSO_4$ $6H_2O$

Thereafter, the % of organic carbon obtained was multiplied by a constant of 1.724 to obtain the organic matter content of the sample soil (Buckley *et al* 2011). The nitrogen content of the soil samples was determined after digestion of the samples with concentrated H_2SO_4 in the presence of Kjeldahl catalyst (Bremner and Mulvancy, 1982). Available phosphorus was determined by Bray and Kurtz (1945) extraction procedure. Cation Exchange Capacity (CEC), The exchangeable cations was determined Buckley *et al* (2011) extraction procedure Exchangeable base was determined by using Thomas (1982) method. Exchangeable Acidity (Al^{3+} and H^+): These were extracted with KCL (Thomas, 1982).

3 RESULTS AND DISCUSSION

The physical and chemical properties of different land use types in Ayetoro Gbede, Kogi State are presented in Table 2 and 3.

3.1 Physical Properties:

Table 2, reflects the Particle size distribution of the study area, The textural class of all the land use types considered is Loamy sand both at the top 0-15cm and 15-30cm except for C1a (coffee) at the top soil with sand textural class. All the soil in the various land use types has high percentage of sand above 80%, this is one of the inherent soil properties, Soil has both inherent and dynamic qualities (USDA, 2006). Inherent soil quality is a soil's natural ability to function. For example, sandy soil drains faster than a clayey one. Deep soil has more room for roots than soils with bedrock near the surface. These characteristics are permanent and do not change easily. The inherent quality of soils is often used to compare the abilities of one soil against another, and to evaluate the value or suitability of soils for specific uses.

Table 2: Physical properties of Soils under varying Land use in Ayetoro Gbede of Ijumu Local Government Area

Sample No	Sand	Silt	Clay	Textural class
		0-15cm		
C_1a	83.58	5.28	11.20	**Sand**
C_2a	86.52	2.28	11.20	**Loamy sand**
C_3a	86.52	4.28	9.20	**Loamy sand**
C_4a	87.52	4.28	8.20	**Loamy sand**
		15-30cm		
C_1b	80.52	12.20	7.28	**Loamy sand**
C_2b	83.52	7.28	9.20	**Loamy sand**
C_3b	89.52	1.28	9.20	**Loamy sand**
C_4b	85.27	9.20	3.28	**Loamy sand**

C_1=coffee, C_2=cocoa, C_3=cashew, C_4=cassava

3.2 CHEMICAL PROPERTIES:

From table 3, Soil pH at depth of 0-15cm is slightly acidic for all the land use types except C3a (cashew plantation) which is acidic with a pH value of 4.20, also at the sub-soil (15-30cm) the land use types are slightly acidic except C1b and C4b (coffee and Cassava) that are slightly alkaline with the value 7.15 and 7.42 respectively. Land use system with low pH will affect crop production due to aluminum toxicity in soils with pH value of about 5.5 and increases in intensity as pH decrease (Chude,*et al* 2005). Cashew land use which is acidic has to be limed to increase the pH. (Chude *et al*, (2005). Soil electrical conductivity, this is generally low across all the land use types compared to the critical level of greater than 4 (>4). At the top soil (0-15cm) coffee land use (C1a) has the highest EC of 0.11dsm^{-1}, while at the sub-surface (15-30cm) cashew land use (C4b) has the highest value with 0.34dsm^{-1}. EC measures the salinity of the soil. Higher EC indicate higher salinity which is detrimentally inhibits plant growth, by lowering the osmotic potential of the soil water, thereby reducing the availability of soil water to plant, reduction in water quality and sedimentation problems, (Alan, 1994). Salt tolerant crops instead of sensitive crops should be cultivated in areas with high salinity, as they thrive in saline condition (Alan, 1994). Available phosphorus, available P at the top and sub-soil is low across all the land use types, the highest at the top soil is 9.52ppm which is cassava land use type (C4a) and at the sub-soil the land use with highest P is also cassava (C4b)) with the value 11.19ppm, these values are below the critical value of 15ppm (Aulakh and Garg, 2007); the low P concentration in the studied area could be as a result of P lost from the soil through P-fixation by Aluminum and Iron oxides, leaching and run-off depletion of soil organic matter, low pH, and this could be corrected by broadcast, band or spot application of phosphorus fertilizer to maintain productivity (Aulakh,and Garg, 2007). Soil organic matter for all the land use types at both top and sub soil is below the recommended critical level of 3.4% (Anon, 1990) except the top soil of coffee plantation (C1a) with the value of 3.91. According to Lal, (2002), SOM provides nutrients and habitat for organisms in the soil, provides energy for biological process. The soil with low content of organic content can be improved by combining soils compost, plant or animal waste, or green manure (Crow, 2009). Total nitrogen at both the top and sub-soil (0-15cm and 15-30cm) is considered low in nitrogen, as critical value is 1.5g/kg (USDA, 1993), for optimum crop production. This low N could be as a result of leaching, volatilization, erosion and low organic matter. Therefore application of organic manure may reduce leaching loss (Kramer *et al*., 2006), increase soil organic matter (Buckley *et al*., 2011). Effective cation exchange capacity (ECEC) of the experimental area at 0-15cm depth has the highest value at coffee land use (C1a) with 9.38cmol/kg and highest value was also recorded at 8.16 Cmol/kg at a soil depth of 15-30cm. Organic matter has a very high CEC (Moore, 1998) a higher CEC usually indicate more clay and organic matter is present in the soil , high CEC soil generally have greater water holding capacity than low CEC soil. The value recorded for calcium in all the land use types in both top and sub-soil is above the critical level of 2.0 Cmol/kg (Adeoye, 1998) indicating high values of calcium present in the experimental area. Calcium as a soil amendment helps to maintain chemical balance in the soil, reduces soil salinity, and improves water penetration. The value recorded for magnesium in all the land use types in both top and sub-soil is above the critical value of 0.4Cmol/kg (Adeoye, 1998); this indicates high value of exchangeable magnesium in the soil. Values of K at the top and sub soil is generally low compared to the critical range of 15cmol/kg (USDA ,1993), at the top soil (0-15cm) highest value of K was recorded at coffee land use (C1a) with 2.97Cmol/kg and the lowest is found at cashew land use with the value 1.94Cmol/kg, also at the sub-soil the highest value was observed at coffee land use with the value 2.65Cmol/kg and the Lowest was recorded also at cashew land use with the value 1.73Cmol/kg**.** Potassium balance in plant is important. The K/(Ca+Mg) and K/N balance must be maintained at a proper level to avoid deficiencies of Mg in the first instance and K in the second instance. For sodium (Na), Using USDA (1993) Rating standard, 0-0.1Cmol/kg is low, 01-0.3Cmol/kg is medium while >0.3Cmol/kg is high. In all the land use types both top and the sub-soil has the Na value greater than 0.3 (>0.3Cmol/kg) at both depth (0-15cm and 15-30cm) considered. High sodium (>3%) can lead to soil dispersion and or sodicity. Application of gypsum will reduce the effect of sodicity by replacing sodium with calcium on the cation exchange. For exchangeable acidity, (Aluminum and hydrogen) for top soil (0-15cm) the highest value was recorded at cashew land use type (C3a) with 1.25Cmol/kg and the lowest was found under coffee land use type (C1a) with 0.86Cmol/kg; Also at the sub-soil of (15-30cm) the highest value was recorded at cashew land use type at 1.32Cmol/kg while the lowest was found at cocoa land use type with 0.14Cmol/kg , therefore all the values fell below the critical level of 4.00 Cmol/kg as exchangeable acidity value in soil. The value indicates a moderate acidity or neutral pH value for most soil. High/toxic levels of Aluminum occur on most soils with an acidity problem; if Aluminum percentage is greater than 5% it will affect most plants, (FAO, 2002). Low pH values will require liming of the soil. Effective cation exchange capacity (ECEC) for all the land use types both at the top and sub-soil is within the medium range recommended value of 4-10Cmol/kg (USDA, 1993) Percentage base saturation, coffee land use (C1a) has highest with 91.11% and cashew land use has the lowest at 84.75% at a depth of 0-15cm ,at depth of 15-30cm, cocoa land use has the highest value with 98.15% while cashew land use has the lowest with 83.24%. Basic nutrient is readily available in the studied area, as soils in this area have high values of plant required nutrient, which are available at >80%, this result of PBS agreed with the finding of Mengel (2011), which says that the higher the amount of exchangeable base cation, the more acidity can be neutralized in a short time.

Table 3: Chemical properties of soil under varying land use types in Ayetoro Gbede Ijumu LGA of Kogi State.

Sample No	pH	EC dSm^{-1}	OM (%)	TN g/kg	Available P (ppm)	Ca	K	Mg	Na	EXB Cmol/kg	EXA Cmol/kg	ECEC Cmol/kg	PBS (%)
						→ Cmol/kg ←							
					0-15cm								
C1a	6.99	0.11	3.91	0.11	7.08	3.71	2.97	1.21	0.93	8.82	0.86	9.38	91.11
C2a	6.64	0.31	2.17	0.06	6.90	3.10	2.08	1.13	0.89	7.20	1.12	8.32	86.53
C3a	4.20	0.06	1.17	0.03	6.55	3.31	1.94	1.14	0.56	6.95	1.25	8.20	84.75
C4a	6.71	0.09	1.0	0.02	9.52	3.20	2.49	1.03	0.58	7.30	1.03	8.33	87.63
					15-30cm								
C1b	7.15	0.08	3.01	0.08	6.67	3.05	2.65	1.08	0.63	7.41	0.97	8.38	88.42
C2b	6.55	0.25	2.35	0.06	7.68	3.58	2.03	1.21	0.62	7.44	0.14	7.58	98.15
C3b	5.83	0.11	0.40	0.01	6.19	3.29	1.73	1.08	0.46	6.56	1.32	7.88	83.24
C4b	7.42	0.34	1.60	0.04	11.19	3.06	2.38	0.93	0.62	6.99	1.17	8.16	85.66

Summary, Conclusion and Recommendation

Soil fertility assessment of different land use types in Ayetoro Gbede Ijumu LGA of Kogi State agroecological zone is focused on properties of soil and processes impacted by soil management which determine the fertility of our agricultural soils for sustainable use.

Soil analysis and it interpretation is an important management tool in assessing soil fertility and quality for maintenance of soil fertility and our environment.

From the result obtained through this study, it can be concluded that most soils within the studied area have favourable pH ranged for arable crop production; very low salinity where by tolerant crops can yield satisfactorily. Most of the soils in the studied area fall in the loamy sand textural class. The cation exchange capacity was moderate in value and the percentage base saturation recorded high values from the samples analyzed. According to Jones (1979) sustainable crop production of these soils will require the maintenance of productivity potentials of the soil by moderate application of inorganic phosphorus and organic manure which will boost yield of most crops grown on the soils. Therefore, availability of this baseline information of the studied area, will provide farmers opportunity to be aware of their soil fertility status and appropriate conservation, maintenance, improvement and productive management of these soils.

From this research, I recommend that Soil management which includes: crop rotation , planting of cover crops and leguminous crops such as cowpea, application of organic matter in order to improve soil structure, prevention of erosion should be embark upon in all the plantations. Soil under cashew plantation with acidity problem should be lime appropriately and farmers in the area should avoid using acid-forming fertilizers such as sulfur and phosphorus fertilizers for optimum productivity; flushing /application of gypsum can be embarked upon to reduce the risk of salinity on all the land use considered.

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