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Research Article

Chemical Properties of Soils of Research and Training Farm, Federal University of Agriculture Zuru, Kebbi State, Nigeria

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Abstract

Semi-detailed soil survey was carried out at the research and training farm of the Federal University of Agriculture Zuru. The objectives were to examine the morphological and chemical properties of the soils. A selected area of 16.4ha out of the total land area of the farm 99.9ha was used in the study. The survey was carried out at scale of 1:25,000. An interval of 250x250m was used in auguring. Surface and subsurface soil sample at the depth of 0-15cm, 15-30cm. Three soil profile pits were dug, described and soils sampled from bottom up, to minimize contamination by falling debris. Each soil profile pit was described based on horizon thickness, depth, colour of matrix and mottles, texture, structure, consistency and horizon boundary characteristic. Three soil mapping units tagged FUZ1, FUZ2 and FUZ3 were identified. The soils were slightly acidic (6.82) to moderately acidic (5.84) in pH, the total nitrogen, soil organic carbon, available phosphorus, and basic cations (Ca, Mg, K, Na) were low to moderate according to the rating of Chude (2011).

Keywords: *Chemical, Properties, Soils and Farm.*

1. INTRODUCTION

According to Akinbola (2006), few soil properties can be determined from the soil surface. Therefore, to determine the nature of a soil one must study its horizons or layers. This requires pits or some means of extracting soil samples from the surface to the base of the soil. Only visible and tactile properties of samples can be studied in the field. Soil moisture and temperature regimes are studied by observations of changes over time at points selected to be representative while the other properties of a soil are studied in the laboratory (Cannon and Winter, 2004).

Soil properties are considered as crucial factors on mobility and bioavailability of nutrients. The soil properties such as soil pH, soil texture, soil temperature, moisture, and soil organic matter have a significant effect on plant nutrients (Letho, 1995). Land use change has a substantial impact on soil properties and soil organic carbon stocks, especially in intensively managed soils (i.e crop land, vineyard, land use) (Letho, 1995). Tillage, pesticides, and fertilizer application were presumably the reasons for altered soil quality properties. Intensively used areas may reduce soil ecosystems services such as the capacity for flood retention and carbon sequestration (Daniel, 2020).

Land use management practices changes such as cultivation of steep slopes, overgrazing, and no or limited fallow periods, lack of institutions to enact regulations or laws that enhance sustainable land management practices have remarkable effects on the dynamics of soil properties. Land use changes from forest cover to cultivated land may reduce input or organic residues that lead to a decline in soil fertility, increased rates of soil erosion, loss or organic matter and nutrients (Fikru, et al; 2020).

Organic matter affects both the chemical and physical properties of the soil and its overall health. Properties influenced by organic matter includes, soil structure, moisture holding capacity, diversity and activity of soil organisms, both those that are beneficial availability. It also influences the effects of chemical amendments, fertilizers, pesticides and herbicides (Fikru, et al, 2020).

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted at Research and Training Farm of the Federal University of Agriculture Zuru, Kebbi State located in the extreme south eastern part of the state on a hilly terrain, Zuru town lies on latitude 11026' – 18.4056"N and longitude 5013'798"E. The climate of the area is typical climate, characterized by wet and dry seasons. The dry season is usually from November to May while rainy season from June to October. The area experiences annual rainfall of 1424mm per annum with average temperature of 200C to 270C (Yalmo, 1998).

2.2 Field Study

Semi-detailed soil survey was carried out at the research and training farm of the Federal University of Agriculture Zuru. A selected area of 16.4ha out of the total land area f the farm 99.9ha was used. The survey was carried out at scale of 1:25,000. An interval of 250x250m was used in auguring along the transects to identify soil types and their boundaries. Surface and subsurface sample 0-15cm, 15-30cm depths. Three soil profile pits were dug, described and soil sampled from bottom up to minimize contamination by falling debris.

Each soil profile pit was dug to standard size (200cm long, 100cm wide and maximum depth of 200cm or until an impenetrable layer or water table is encountered. Each pit was described based on morphological characteristics according to established standard procedure (Soil Survey Staff, 1999). The characteristics describes include soil depth, horizon thickness, colour of matrix and mottles, texture, structure, consistency, porosity, included materials, roots and horizon boundary. In addition, records of vegetation/land use, slope, depth to water table and internal drainage status was obtained for each profile. Three soil mapping units tagged FUZ1, FUZ2 AND FUZ3 were identified.

2.3 Laboratory methods

Soil pH was determined with the aid of glass electrode pH meter (Adesanwo *et al*, 2013). Electrical conductivity was measured using electrical conductivity meter (Simon, 2000). Soil organic carbon was determined by the acid-dichromate oxidation method of Walkley and Black (1934). Total nitrogen was determined by digestion distillation method using micro Kjeldahl technique (Bremner and Mulvaney, 1982). Available Phosphorous was determined following the procedure described by IITA (1979) using Bray – 1 extraction method (Bray and Kurtz, 1945).

Exchangeable bases (Ca, Mg, K, and Na) in the soil were extracted with 1.0m ammonium acetate (NH4OAC) extracting solution buffered at pH7. Exchangeable Ca and Mg was determined by EDTA titration (Ahukaemere et al, 2014). Exchangeable K and Na was determined using Flame Photometer. Percentage of base saturation was calculated as the summation of the exchangeable bases (Ca, Mg, K and Na) divided by the cation Exchange Capacity (CEC) and their quotient
multiply by 100 (Kissel, 2008).

$$\text{PBS} = \frac{\sum \text{Ca,Mg,K and Na}}{\text{CEC}} \text{ x } 100$$

The CEC was determined by neutral ammonium acetate method buffered at pH7. (Rhoades, 1982).
The ESP was calculated as:

$$\text{ESP} = \frac{\text{Exchangeable (Na)}}{\text{Ca+mg+k+Na}} \text{ x } 100$$

Sodium Adsorption Ratio was calculated as the ratio of the Na concentration divided by the square root of one-half of the Ca+Mg concentration.

$$\text{SAR} = \sqrt{\frac{1}{2}\left(Ca^{2+} + Mg^{2+}\right)}$$

The data was analyze using descriptive statistics such as means and weighted averages.

3. RESULTS AND DISCUSSION

The Morphological and chemical properties of the soils are presented in tables 1 and 2 respectively

3.1 Soil morphological properties of the soils

The morphological properties of the soils are presented in table 1

The morphological properties of the soils are presented in Table 1. The soils of all pedons are generally deep with depth of >140cm. The colour of the soil varied from very pale brown (10YR 2/2) in the surface horizon changing to dark yellowish brown (10YR 3/3) in the subsurface horizon. The texture of the soil varied from loamy sand to loam in the surface horizon changing to clay loam to silt loam in the subsurface horizon with strong angular blocky structure in the surface horizon changing to sub-angular blocky structure in the subsurface horizon. Similar result was found by (ESU, 2004). The consistence of the soils is sticky/plastic in both surface and subsurface of pedon 1, pedon 2 friable and 3 loose. The roots of the soils varied from many roots changing to few roots in the surface horizon and very few roots to no roots in the subsurface horizons. The horizon boundary of the pedon was smooth diffuse in the surface horizon and subsurface. The morphological characteristics of FUZ1 revealed features indicative of moderate profile development under seasonal wetness. The horizons display low organic matter content due to the exhibits of silty clay and illuviation of sand where finer particles accumulate due to percolation of water from the surface (Soil Survey Staff, 1999). The presence of grayish matrix colours and mottles indicates seasonal saturation and reduced conditions, a sign of imperfect drainage and gleying (Esu, 1999). Overall, the morphological features of FUZ1 shows vertical differentiation driven by clay translocation, periodic wetness and moderate soil development, such features are consistent with soils formed under alternating wet and dry tropical conditions. This is in line with finding of (ESU, 2004).

The morphological description of soil profile of FUZ2 revealed the presence of transitional horizons (ABg, ABI, AB2) which indicates gradual changes in soil formation and horizon development, possibly due to illuviation, clay migration or weak pedoturbation. This tallies with soil survey staff (1999) findings. The deeper horizons (AB1 to BC) indicates less organic matter, increased leaching or oxidized conditions (FAO, 2006). The dominance of sandy loam in upper layers indicates coarse material likely from parent materials or alluvial deposition. The transition to finer textures in lower horizons signifies clay illuviation which can affect water retention and root penetration. This is in line with (Landon, 1991) findings. The soils also increased compaction, clay content and low organic matter, potentially limiting root penetration and drainage (ESU, 2004).

The morphological characteristics of profile FUZ3 revealed moderate development of structure due to minimal clay content and weak aggregation. The light color of the soil showed typical of sandy soils with low organic matter content (Brady and Weil 2016). The friable consistency and many pores indicates good aeation and ease of tillage in the topsoil which is favourable for root growth and penetration but with limitations due to reduced porosity and nutrient status. This is agreed with the findings of Soil Survey Staff (1999). The lack of organic matter indicates poor biological activity and limited permeability. These conditions are common in deep subsoils of tropical Alfisol or Entisols with weak pedogenic development (FAO, 2006). The lack of mottling throughout the profile indicates good drainage conditions, confirming the soil is well-aerated and likely free from seasonal waterlogging, which is beneficial for most crops (Brady and Weil, 2016). The morphological properties indicates that FUZ3 is a young to moderately developed soil with weak horizon differentiation, good drainage, and low organic matter. Such soils typically require soil amendment (Eshett, 2003).

Table 1: Morphological Properties of the Soils

Horizon	Depth (cm)	Munsell color (moist)	Texture	Structure	Pores	Mottling	Consistency (moist)	Root	Horizon boundary
FUZ 1 (Aquic Dystrusterts)									
Ap	0-17	10RY 6/3	LS	ABK	MP	10YR 3/6	SP	MR	D
ABg1	17-47	10RY 3/2	SL	ABK	FWP	10YR 3/4	SP	FWR	SD
ABg2	47-82	10YR 3/3	CL	SABK	FWP	10YR 3/6	SP	VFWR	SD
BCg	82-141	10YR 3/4	Sic	ABK	NP	10YR 4/6	SP	NR	SD
FUZ 2 (Haplustalfs)									
Ap	0-20	10YR 5/3	SL	ABK	FWP	None	F	FWR	DS
ABg	20-56	10YR 6/4	SL	ABK	FWP	10YR5/3	F	VFWR	DS
AB1	56-124	10YR 8/6	SL	SABK	NP	None	F	NR	DS
AB2	124-178	10YR 7/4	Sic	ABK	NP	None	F	NR	DS
BC	178-200	10YR 8/4	CL	SABK	NP	None	F	NR	DS
FUZ 3 Fluventic (Dystroxerepts)									
Ap	0-31	10YR8/6	S	SABK	MP	None	L	FWR	DS
AB	31-83	10YR 6/8	SL	ABK	MP	None	L	FWR	DS
BC	83-200	10YR 8/4	SL	ABK	FWR	None	L	NR	DS

Texture: S = Sandy, LS = Loamy Sand, SL = Sandy Loam,
Structure: ABK = Angular blocky, SBK = Sub-Angular Blocky, SIL = Silt,
Colour: 10YR 6/3 = Very pale brown, 10YR 3/3 = Dark brown, 10YR 3/2 = Brown 10YR ¾ = Dark Yellowish brown, 10YR 5/3 = Brown, 10YR 5/4 = Light Yellowish Brown, 10YR 8/6 = Yellow, 10YR 7/4 = Very pale brown, 10YR 8/4 = Very Pale Brown, 10YR 6/8 = Brownish yellow,
Consistence: SP = Sticky/plastic, F = Friable, L = loose
Roots: MR = Many Roots, FWR = Few Roots, VFWR = Very Few Roots, NR = No Roots,
Boundary: D = Diffuse, DS = Diffuse Smooth,

Chemical Properties of the Soils

The chemical properties of the soils are presented in table 2.

The pH in all the pedons fall within moderately acidic range (5.73-5.66), this could be attributed due to the downward movement of the basic cation along the slope and tends to increase with depth. Jamalu and Oke (2013) reported similar result. In case of FUZ3 pH value was close to neutral due to the high leaching down of basic cation. The EC values in all the pedons indicates that the soil in the mapping unit were slightly saline (2.08dSm^{-1}, 1.14dSm^{-1} and 1.70dSm^{-1}). Similar result was reported by Smith and Doran (1996). The SOC values in all the pedons fall within very low range (2.78g/kg^{-1}, 1.29/kg^{-1} and 1.76g/kg^{-1}) this could be attributed to factors such as continuous cultivation, frequent burning of farm residues without replenishing them. Similar result was reported by Landon (1999). The TN values of all the pedons fall within low range due to the reflect losses through leaching and crop removal. (Noma *et al;* 2004) reported similar result. AvP values (3.24mg/gk, 3.15mg/kg and 3.14mg/kg) of all the pedons were within medium range. The values of calcium in the soil are presented in table 4.2. The average calcium values for FUZ1, FUZ2 and FUZ3 were 1.06cmol/kg, 0.81cmol/kg and 1.05cmol/kg respectively. The calcium values in all the pedons fall within very low range. This agrees with Sharu *et al.* (2013) findings which also corresponded with the findings of Noma *et al,* (2004).

The very low calcium values of the soils could be attributed to downward movement of basic cations as primarily reported by Singh et al. (2001) in the study of exchangeable calcium on Fadama soils in Kandoli, Shela stream valley, Sokoto State, Nigeria. The exchangeable magnesium in the values in all the pedons (FUZ1, FUZ2 and FUZ3) were 0.30cmol/kg, 0.22cmol/kg and 0.36cmol/kg respectively. The exchangeable magnesium values in all the pedons falls within low range. The low exchangeable magnesium values of the soils could attributed to leaching down of magnesium due to heavy rainfall as reported by Esu (1991). It was also similar with findings of Yakubu et al. (2006). The exchangeable potassium in the all pedons were 0.06cmol/kg, 0.08cmol/kg and 0.10cmol/kg (FUZ1, FUZ2 amd FUZ3) respectively. The average values of all in the pedons fall within very low range in comparisons with the rating of Esu (1991). The low of exchangeable potassium could be attributed to high Mg in the soil which could have caused K deficiency in soil with high Mg tends to have poor structure primarily reported by Noma et al. (2004) in the study of the soil of Sokoto State. The exchangeable sodium values in the soils are presented in table 4.2. the mean values of FUZ1, FUZ2 and FUZ3 were 0.19cmol/kg, 0.12cmol/kg and 0.11cmol/kg respectively. The exchangeable sodium values in all the pedons fall within low range. This could be attributed to intense leaching resulting from high rainfall experienced in the study area as reported by Jones. (1973). The exchangeable sodium of the soil increased with depth which range from 0.19cmol/kg to 0.22cmol/kg in the surface horizon while that of the subsurface horizons varied from 0.09cmol/kg to 0.15cmol/kg.The CEC of the soil is presented in table 4.2. The average CEC values for FUZ1, FUZ2 and FUZ were 1.94cmol 17.6 cmol/kg and 21.6cmol/kg respectively. The FUZ3 had the highest mean value which might be attributed to the deposition of the basic cation in the soil of the study area. The CEC values of all in the pedons fall within moderate class of 12-25cmol/kg-1, this is as in the ratings of Halzeton and Murphy (2007). The CEC in the surface horizons were in the same range with that of the subsurface horizons in all the pedons. The ESP of the soils is presented in the table 4.3. the mean values of all the pedons were 12.4%, 11.68% and 8.0% of FUZ1, FUZ2 and FUZ3 respectively. The ESP values in all the pedons fall within moderate percentage range (8.0%-12.4%). This is in line with the (DPIRD, 2021) ratings <6 non sodic, 6-10 slightly sodic, 6-15 moderately sodic and >15 Highly sodic. The SAR values of the soils are presented in the table 4.3. The mean values of all the pedons of FUZ1, FUZ2 and FUZ3 were 0.22%, 0.18% and 0.13% respectively. The SAR values in all the pedons fall within very low percentage range. This was in comparison with Halzeton and Murphy (2007). The PBS of the soils in presented in table 4.3. The mean values for all the pedons of FUZ1, FUZ2 and FUZ3 were 8.27%, 6.99% and 7.56% respectively. The PBS values fall within very low percentage range in comparison with Metson (1961) ratings (0-20% very low, 40-60% moderate and >60% high).

Table 2: Chemical Properties of the Soils

Horizon	Depth (cm)	pH (water)	E.C (dS m^{-1})	SOC (g/kg $^{-1}$)	TN (g/kg)	AP (mg /kg-^{1})	Ca (cmol/kg)	Mg (cmol/kg)	K (cmol/kg)	Na (cmol/kg)	CEC (cmol/kg)	ESP %	SAR %	PBS %
FUZ 1 (Aquic Dystrusterts)														
AP	0-17	5.27	3.05	2.81	0.82	3.21	0.51	0.34	0.04	0.19	19.7	17.59	0.22	5.48
ABg1	17-47	5.97	2.16	2.69	0.79	3.17	1.38	0.31	0.07	0.20	19.4	10.20	0.21	10.10
ABg2	47-82	5.85	1.63	2.71	0.76	3.21	1.39	0.28	0.06	0.22	19.4	11.20	0.24	10.05
BC	82-141	5.84	1.46	2.92	0.84	3.24	0.95	0.27	0.06	0.15	19.2	10.48	0.19	7.44
	Mean	**5.73**	**2.08**	**2.78**	**0.80**	**3.24**	**1.06**	**0.30**	**0.06**	**0.19**	**19.4**	**12.4**	**0.22**	**8.27**
FUZ 2 (Typic Haplustalfs)														
AP	0-20	5.47	1.39	1.20	0.51	3.16	0.40	0.20	0.05	0.16	17.6	19.75	0.29	4.60
ABg	20-56	5.91	0.92	1.16	0.47	3.14	0.59	0.21	0.06	0.12	17.8	12.24	0.19	5.50
AB1	56-124	6.08	1.21	1.38	0.63	3.14	0.58	0.22	0.08	0.11	17.8	11.11	0.17	5.56
AB2	124-178	5.09	1.22	1.36	0.63	3.15	0.58	0.23	0.07	0.10	17.5	11.09	0.15	5.54
BC	178-200	5.76	0.96	1.37	0.61	3.15	1.89	0.24	0.15	0.10	17.3	4.20	0.09	13.75
	Mean	**5.66**	**1.14**	**1.29**	**0.57**	**3.15**	**0.81**	**0.22**	**0.08**	**0.12**	**17.6**	**11.68**	**0.18**	**6.99**
FUZ 3 (Flueventic Dystroxerepts)														
Ap	0-31	6.82	1.79	1.32	0.64	3.14	0.36	0.36	0.10	0.11	21.4	11.82	0.18	4.34
AB	31.83	6.55	0.93	1.36	0.61	3.13	1.46	0.35	0.12	0.09	21.6	4.45	0.06	9.35
BC	83-200	6.21	2.35	2.61	0.71	3.15	1.34	0.36	0.09	0.15	21.6	7.73	0.16	8.98
	Mean	**6.53**	**1.70**	**1.76**	**0.65**	**3.14**	**1.05**	**0.36**	**0.10**	**0.11**	**21.6**	**8.0**	**0.13**	**7.56**

EC = Electrical Conductivity, SOC = Soil Organic Carbon, TN = Total Nitrogen, AP = Available Phosphorus, Ca = Calcium, Mg = Magnesium, K = Potassium, Na = Sodium, CEC = Cation Exchange Capacity, ESP = Exchangeable Sodium percentage, SAR = Sodium Absorption Ratio, PBS = Percent Base Saturation.

4. CONCLUSION

The study revealed that the soils in all the pedons were moderately acidic especially in FUZ1. It is also revealed to have moderately low in natural fertility with low basic cation (Ca, Mg, K, Na) organic carbon, cation exchange capacity, total nitrogen from the results on chemical properties, which revealed that most of the nutrients were low in quantity.

5. RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:-

Liming should be carryout going by the acidic nature of the soils of FUZ1 to improve its conditions.

Given general low fertility of the soils, organic and inorganic fertilizer should be applied to improve the fertility conditions of the soils.

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