Assessment of Properties of Fadama Soils in Jos North Local Government Area of Plateau State

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ABSTRACT

The study was conducted in Jos North L.G.A of Plateau State, Nigeria to assess the properties of Fadama soils. Soil samples were collected from Federal College of Forestry Jos, Federal Department of Forestry, Farin Gada and ECWA Staff Fadama sites at two depths (0 – 15cm and 15 – 30cm) using simple random sampling methods. The parameters assessed for were particle size distribution, P^H, total Nitrogen, organic carbon, organic matter, available phosphorous, total exchangeable bases, exchangeable acidity, cation exchange capacity, base saturation percentage, exchangeable sodium percentage and sodium absorption ratio. Results obtained indicate that the soils were generally clay to clay loam in texture. The organic carbon ranges from 0.082 – 1.68%, total nitrogen 0.041 – 0.084%, available P 6.70 – 24.5ppm, Calcium 2.50 – 4.35ppm and available potassium 0.22 – 0.48ppm. These contents studied were very low. Magnesium and Cation exchange Capacity varied from medium to high , while soil P^H ranges from 6.11 – 6.69, Exchangeable Sodium Percentage (0.24 – 0.38%) were very low indicating no salinity/sodicity risks. The slightly acidic reaction and low nutrient status of these soils could culminate into acid soil fertility. Declined in soil fertility have capitulated decreased in food production. A guide to the achievement of sustainability of crop production entails application of organic manure, inorganic fertilizer and liming materials simultaneously to boost and stimulate soil fertility as well as raising the soil PH. This study outlines the role of fadama soils as an answer to sustainability and renewability of crop production for economic development in the study area.

Key words: Physico-chemical properties, Fadama farm soils, Ekiti State, Nigeria.

INTRODUCTION

Fadama soils are low-lying areas including stream channels and stream less depressions, which are waterlogged or flooded in wet season (Turner, 1977). They are found scattered in the arid and semi-arid tropical regions. In Nigeria today, the need for increased food production to feed the ever-increasing human population and to diversify the export base of the country is more recognized now than ever before. This has turned the attention of both farmers and governments to the exploitation of Fadama lands which are believed to have more agricultural potential than the associated upland soils (Esu, 1999, Kpamwang and Esu, 1990). Due to massive production of agricultural produce on the Jos, Plateau, excessive washing away of the topsoil layer through erosion has drastically reduced the food productivity in Plateau State. According to Walsh (2003) the presence of salts in the soil that has accumulated over the years has affected crop productivities, excessive mining activities, climatic trends that favour salts disposition, salt from underground water, heavy rainfall, soil erosion, pedagogical and morphological properties of the soil are the fundamental factors generating soil sodicity and salinity in all Fadama soils of Jos (Juo, 1979).

Until recently, little attention has been given to Fadama lands. However with the realization that population in Nigeria is growing at an alarming rate while food supply is slow, utilizing the use of the limited land resources become more pronounced. Therefore, soil fertility is affected by salinity, sodicity, water holding capacity in Fadama soils of Jos and its environments. It is of great significance to utilize the fadama soil for effective agricultural production (Kwowal, 1972) since the climate favours agricultural production on the Plateau, it is therefore essential to put into use the gift of nature. The fadama soils are highly rich in nutrients deposits in the plains as the flood water recede. According to (Ipinmidum, 1997) large volumes of sediments are seasonally discharged into the floodplains which helps to renew the fertility of the soils.

Importance of Fadama soil is that it has high moisture content (ground water and residual moisture) even during seasons as well as drought. The ground water is at the soil surface which aid plant growth and development and enable farming activities suitable throughout the ear (Singh, 2003).The need for an effective use of Fadama soil cannot be overemphasized especially when viewed against the realization that such information forms the background to the efficient and judicious use of the resources. Fadama soil varies widely in their physiochemical properties. This is attributed in the different deposition of materials eroded from the surrounding upland and those transported from elsewhere during the raining seasoning (Singh *et al.,* 1996).

Materials and Methods

Soil Sample Preparation

Soil samples were taken from two Fadama farms located at Federal College of Forestry demonstration farm and Farin Gada Vegetable farm in Jos North L.G. A. of Plateau state.

soil samples were collected from a depth of 0-15cm and from 15-30cm using soil augar and was put into a polythene bag and each of the soil were labelled accordingly from the four different sites in each location where the soil samples were taken. The bulk soil samples collected were air-dried in the laboratory for several days. Sample were crushed gently with porcelain pestle and mortar and passed through a 2mm sieve to remove coarse fragments. The fine earth separates (2mm soil portion) were stored in polythene bags for analysis. The gravely portion retained on the 2mm sieve (stones and gravels) were weighed and its percentage to the whole soil; were also calculated. Particle size distribution was determined by the hydrometer method (Gee and Bauder, 1886).

PHYSICAL AND CHEMICAL ANALYTICAL METHODS:

Physical Properties

In the laboratory, undisturbed samples were air dried, crushed and passed through 2mm diameter sieves for analysis will be used to carry out the process, this was determined by direct sieving followed by weighing. Sand, silt and clay were determined by dispersing the soil samples in 5% Calgon (sodium hexametaphosphate) solution. The dispersed samples were shaken on a reciprocating shaker after which particle size distribution were determined with the aid of Bouyoucous hydrometer at progressive time intervals. The textural classes were determined with the aid of USDA textural triangle.

Chemical Analysis:

The following chemical analysis shall be carried out:-

Soil pH

The soil was determined, both in water and O.OIM $CaCl_2$ solution, using a soil to solution ratio of 1:2.5 (IITA, 1979). On equilibration, pH was read with a glass electrode on a pyeunicam model 290Mk pH meter. Delta pH (dpH) values were determined as follows:

$dp^H = P^H (CaCl_2) - p^H (H_2O)$.

1 exchangeable bases.

Exchangeable Bases

Exchangeable Ca, Mg, N, and K were extracted with 1M Ammonium Acetate (1M Nr^OAc) solution buffered at pH 7.0, as described by Anderson and Ingram (1998).

Potassium and Sodium in the extract would be read on a Gallen Kamp flame Analyzer. The extract was diluted two times with the addition of 2ml of 6.5% Lanthanum chloride solution to prevent ionic interference before Ca and Mg were read. The Ca and Mg were read on a PyeUnicam model SP 192 atomic absorption spectrophotometer (AAS) at 423 and 285nm wavelength respectively. The sum of Ca, Mg, Na, and K were total M KCI extract would be

Exchangeable Acidity

The soils were leached with 1M KCI solution. Exchange acidity (Al + H) in the determined by titrating with 0.1M sodium hydroxide solution as described by (Anderson and Ingram, 1998).

Effective CEC

Effective CEC was calculated from the summation of exchangeable bases determined by 1M NH_4OAC extraction and the exchange acidity by 1M KCI extraction (Anderson and Ingram, 1998).

ECEC (Cmol kg^{-1}) = Exch. ($K^+ + Ca^{++} + Mg^{++} + Na^+$ + Acidity)

Base Saturation (BS)

Percentage saturation was calculated by dividing the total exchangeable cat ion (Ca, Mg, K and Na) by the cat ion exchange capacity (CEC) obtained by the 1M NK_4OAC (P^H 7.0) method as follows:

% BS = Total exchange bases x 100 CEC (NH_4OAC)

Exchange Sodium Percentage

The exchangeable sodium percentage was calculated as the proportion of the CEC (NH_4OAC), occupied by exchangeable sodium as follows:

ESP = changeable sodium x 100 CEC (NH_4OAC)

Organic Carbon

The organic carbon was determined by the wet oxidation method of Walkley -Black as described by Nelson and summer (1982) the reaction was activated with the addition of concentrate sulphuric acid as a catalyst.

Total Nitrogen

The total nitrogen content of the soil was determined using the micro-kjeldahl technique as described by Bremner (1982). Free ammonia liberated from the solution by steam distillation in the presence of 10M NaOH was collected. The distillate was then titrated with 0.1M I-^SO,}.

Available Phosphorus

Available phosphorus was extracted using the Bray No. 1 method (Bray and Kurtz, 1945). Phosphorus in the extract was determined calorimetrically by the Molybdophosphoric - blue method using ascorbic acid as a reducing agent (Murphy and Riley, 1962).

Organic Phosphorus

Organic phosphorus was determined by ignition method as described by Anderson and Ingram (1998). The soil organic matter was destroyed by igniting the soil samples at 550°C in a muffle furnace. The difference between the acid extracted P of an ignited soil sample and unignited soil sample, gives the measure of soil organic P.

Total Sulphur

Total sulphur in the soil water was determined by the conversion of sulphur containing compounds into S(V^2 by oxidation as described by Agbenin (1995). The sulphur in the extract was turbidimetrically determined on a colorimeter at 470nm.

RESULTS AND DISCUSSIONS

4.1 Physical properties

The physical properties of fadama soil presented in Table 1 shows that, the soils in FCF and Farin Gada area are dark grey (7.SYR 4/0) at the surface (0 – 15cm) and subsurface (0 – 30cm) in colour respectively while at FDF and ECWA staff showed grey (80.75 YR 5/0) colouration at both surface and sub surface horizones .

Table 1: Physical Characteristics

Location	Depth	Horizon/Colour	Sand%	Silt%	Clay %	Textural class
FCF	0-15	7.5 YR 4/0 Dark grey	34	27	39	Clay loam

FCF	15–30	25-43 YR 4/0 Dark grey	32	26	42	Clay
FDF	0-15	43-80.75 YR 5/0 Grey	38	24	38	Clay loam
FDF	15-30	80-100 7.5 YR 6/0 Grey	35	24	41	Clay
Farin-gada Farin-	0-15	0.27 7.5 YR 4/0 Dark grey	37	24	39	Clay loam
gada ECWA	15-30	27-50 25-43 YR 4/0 Dark grey	34	25	41	Clay
STAFF ECWA	0-15	43-80.75 YR 5/0 Grey	36	28	36	Clay loam
STAFF	15-30	80-100 7.5 YR 5/0 Grey	30	28	42	Clay

The surface soils (0-15cm) in both locations were of clay loam textural classes while the subsurface soils were observed to have clay textural classification. This may be attributed to leaching of the fine textured particles down the profile. In all the locations, sand percent was found to have a decreasing distribution pattern with soil depth whereas soils were observed to have an irregular distribution pattern. Similarly, clay had an increasing distribution pattern with soil depth.

4.2 CHEMICAL PROPERTIES

4.2.1 Soil P^H

The average P^H value for ECWA staff fadama area was 6.57 as shown in table 2, 6.44 for Farin Gada, 6.25 for FCF and 6.16 for FDF fadama sites. This indicates that the P^H value for the study area is slightly acidic according to Esu (1999) rating. Similar trend were also observed and reported by Enokela and Salifu (2012) having a pH value of 6.50. The soil pH is found to increase with depth.

Total Nitrogen

The total percentage nitrogen in at the sites shows FCF having 0.078%, FDF has 0.061, ECWA staff has 0.051 and Farin Gada with 0.045%. The result indicates that high percentage nitrogen was recorded at FCF. Similar result to ECWA staff of low nitrogen values as reported by Kparmwang (1996) having nitrogen value of 0.051% was obtained in Bauchi state. The total nitrogen of the area shows an irregular pattern of distribution vertically down the soil profile, similar result were also reported by Sharu *et al.*, (2013) in Sokoto state. These irregular changes could be as a result of continuous cultivation, a practice which is common in the area, which is accompanied by nearly crop residue removal (Noma et al. 2011).

Organic Carbon

The organic carbon in the four locations was found to be generally low, according to London (1991) rating. Federal College of Forestry farm has a mean value of 1.56% 1.22% at Federal Department of Forestry, 1.15% at ECWA staff and 0.53% at Farin Gada. The surface mean is

Table 2: **CHEMICAL CHARACTERISTICS**

Location	Soil Depth (cm)	PH					Available Phosphorus (ppm)	Exchangeable Base in (ppm)					CEC cmol/kg	BS%	ESP %	SAR %
		H2O	CaCl2	Total % Nitrogen	Organic Carbon %	Organic matter %		K	Ca	Mg	Na	Exchangeable acidity cmol/kg				
FCF	0-15	6.18	5.12	0.084	1.68	2.92	24.5	0.36	4.00	2.00	0 02	1.63	7.98	79.94	0.25	0.008
FCF	15-30	6.32	5.20	0.071	1.43	2.45	17.5	0.48	4.35	2.10	0.026	1.60	8.56	81.26	0.30	0.01
Average		**6.25**	**5.62**	**0.078**	**1.56**	**2.68**	**21.0**	**0.42**	**4.18**	**2.05**	**0.023**	**1.62**	**8.27**	**80.6**	**0.28**	**0.009**
FDF	0-15	6.11	5.06	0.062	1.24	2.14	14.0	0.24	2.30	1.00	0.014	1.65	5.20	68.35	0.27	0.008
FDF	15-30	6.20	5.18	0.059	1.19	2.06	17.3	0.32	2.45	1.10	0.021	1.67	5.56	69.98	0.38	0.011
Average		**6.16**	**5.12**	**0.061**	**1.22**	**2.10**	**15.61**	**0.28**	**2.38**	**1.05**	**0.018**	**1.66**	**5.38**	**69.17**	**0.33**	**0.01**
Farin gada	0-15	6.31	5.04	0.049	0.99	1.70	7.00	0.29	2.50	1.00	0.017	1.59	5.00	73.33	0.31	0.009
Farin gada	15-30	6.50	5.24	0.041	0.082	1.42	6.70	0.39	2.80	1.70	0.024	1.64	6.53	74.95	0.37	0.011
Average		**6.44**	**5.14**	**0.045**	**0.53**	**1.36**	**6.85**	**0.3**	**2.65**	**1.35**	**0.21**	**1.61**	**5.97**	**74.14**	**0.34**	**0.01**
ECWA STAFF	0-15	6.45	5.22	0.062	1.24	2.41	14.0	0.22	2.25	1.15	0.013	1.72	5.35	67.91	0.24	0.007
ECWA STAFF	15-30	6.69	5.02	0.053	1.06	1.82	7.00	0.27	2.50	1.35	0.018	1.77	6.07	68.17	0.30	0.009
Average		**6.57**	**5.12**	**0.051**	**1.15**	**2.11**	**10.5**	**0.24**	**2.37**	**1.25**	**0.015**	**1.74**	**5.71**	**68.04**	**0.27**	**0.008**

significantly decreased with the soil depth as suggested by Browaldh (1995). The organic carbon tends to be more in surface depth as opined by Sharu et al,(2013), who also reported similar results having a value of 1.38% organic carbon. The high organic carbon at the surface soil in the study area could be as result of leaching.

Organic Matter

The mean organic matter (%) for F.C.F is 2.68% and 2.11% for ECWA staff. while for FDF and Farin Gada are 2.10% and 1.36% respectively. The low organic matter content of soils has been attributed to factors such as continuous cultivation, frequent burning of farms, and plant residues commonly carried out by farmers in the area which tends to deplete organic materials that could have been added to the soil, Yakubu (2001) reported the same result having the organic matter of 2.36%. Furthermore, Agbu and Ojanuga(1998) stated that low organic matter content in soils could be due to rapid decomposition and mineralization of organic materials contributed by sparse vegetation in the Guinea savannah region as promoted by radiation.

Available Phosphorus

Federal College of Forestry has a mean value of 21.00ppm and 15.61ppm at FDF, ECWA staff has 10.50ppm while in Farin Gada the value is 6.85ppm. The available phosphorus content varies from each of the locations and has an irregular phosphorus distribution pattern. Aluko (2000), stated that plant depend mainly on phosphorus for biomass production, plant growth and development. The phosphorus content in Farin Gada is recorded as significantly very low in both surface and subsurface horizons in the study area. Same result were also obtained from Sharu *et al.,* (2013) with a value of 15.35 (ppm) of available phosphorus in Sokoto state. Brady and Weil, (2002) stated that the lower level of available phosphorus, particularly in fadama soils could be due to phosphorus fixation into unavailable forms such as calcium phosphate, which could be attributed to large quantities of calcium deposited in the farm through irrigation water and flooding water.

Cation Exchange Capacity

The result also indicates that at F.C.F the CEC is 8.27cmol/kg and farin Gada a value of 5.97cmol/kg^{-1} while at ECWA staff it is 5.71cmol/kg^{-1} and 5.38 cmol/kg at FDF. CEC in the study area has an irregular distribution pattern in both surface and subsurface horizon as shown in table 2. Generally the cation exchange capacity ranges from low to very low, according to rating by Ilaco (1985). Sharu et al (2013) also reported similar result, having an CEC of 6.81cmol/kg in Kano State. The low exchange capacity of the soils may be as a result of the nature of clay (kaolinite) minerals (Opuwaribo and Odu, 1988; Juo and Moorman, 1981, Hassan et al., 2011). Yakubu et a; (2011) opined that organic matter content of soils may normally influence CEC which is generally low and therefore the low CEC values may be attributed to the amount of organic matter.

Exchangeable Bases

Available Potassium: Available potassium ranged from 0.42ppm to 0.24ppm at in the study area. Available potassium increases downwards along the horizon. The available potassium in the study area is very low due to organic matter content which is known to have influence in its availability. Ipinmidun (1970) also reported that potassium is the most deficient elements in fadama soils. Ilaco (1985) ratings shows that all the soils are generally low in potassium. Sharu *et al* (2013), stated that, magnesium problem are frequent when the soil K:Mg ratio exceed 1.5:l, high Mg soils cause K deficiency in plant and soils with high Mg tends to have poor structure.

Calcium and Magnesium Status

Calcium contents in the four locations indicates a range of 4.18ppm – 2.37ppm. From the results obtained, it shows tha calcium content is higher in F. C. F compared to other locations. Similar results of 3.50cmol/kg^{-1} of calcium were obtained in Bokkos, Mustapha and Nnalee (2007) in Jos Plateau fadama soils.

Magnesium content of 2.05ppm to 1.05ppm in the four locations. These patterns of distribution vary with soil depth, this shows that magnesium content is dominant in FCF compared to the three other sites. According to rating by ILaco (1985) the soil in FCF has high magnesium content compared to that of three other sites with high accumulation of magnesium content. Magnesium was found out to be relatively high in the study area and have a dominant base in Fadama soil (Kowal and Knabe, (1978). Similar results were obtained from Mustapha and Nnalee having a similar results of 1.61 cmol/kg of magnesium in Bokkos (2007) in Jos Plateau Fadama Soils.

Sodium Status

The Farin Gada mean value of 0.21ppm was obtained and FCF has a value of 0.023ppm while in FDF and ECWA staff the mean value of 0.018ppm and 0.015ppm respectively were obtained as shown in table 2. It then means that, the fadama soils have low sodium on its exchangeable cation complex according to rating by Ilaco (1985).

Exchangeable Acidity

The exchangeable acidity refers to the amount of acid cations (aluminium and hydrogen) occupied on the cation exchange capacity (CEC), the range of exchangeable acidity is 1.59 to 1.64cmol/kg at the two locations. For Federal College of Forestry at a depth of 0 – 15cm and in Farin Gada at the same depth the exchangeable acidity has a mean value of 1.63 and 1.59 respectively. At the same depth of 15 -30cm it is 1.60 and 1.64 at both locations as shown in table 2.

Base Saturation

The base saturation in ECWA staff was found to be 1.74, 1.66 for FDF, 1.62 for FCF and 1.61 for Farin Gada. These shows a decrease in the subsurface of the horizon due to the accumulation of organic matter and rock deposition brought about by weathering of parents material in relation to the increased alluvial deposition down the soil depth. FAO (1999) reported that soils with base saturation of greater than 50% are regarded as fertile soils while soils with less than 50% are regarded as infertile soils. Based on these facts therefore, the soils in all the two locations are generally fertile.

Exchangeable Sodium Percentage (ESP)

The range of values for exchangeable sodium percentage in the soils in the four locations was 0.34% - 0.27%. Yakubu et al (2001) having an ESP of 0.31% also reported similar result in soils of Sanyinna area of Sokoto state.

Sodium Adsorption Ratio (SAR)

SAR ranges from 0.01 at Farin Gada and FDF respectively to 0.09 at FCF and ECWA staff as shown in Table 2. Sodium Adsorption Ratio (SAR) are for the locations fall below the threshold value of 13 for sodic soils (Sanda *et al.*, 2007). Similar results were obtained by Sharu *et al.* (2013) having an SAR of 0.014% in the soils of Dingyadi district of Sokoto State.

Conclusion

The slightly acidic reaction and low nutrient status of these soils could culminate into acid soil fertility. Declined in soil fertility have capitulated decreased in food production. A guide to the achievement of sustainability of crop production, entails application of organic manure, inorganic fertilizer and liming materials simultaneously to boost and stimulate soil fertility as well as raising the soil PH. This study outlines the role of fadama soils as an answer to sustainability and renewability of crop production for economic development in the study area.

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