Evaluation of Fertility status of soils under Bamboo (*Bambusa vulgaris*) in Akamkpa and Odukpani Local Government Areas of Cross River State, Nigeria

Bello, O. S. and Akpa, E. A.

Department of Soil Science, University of Calabar, P.M.B. 1115, Calabar, Cross River St., Nigeria

Corresponding author: enyaanari@gmail.com

ABSTRACT

The aim of this research was to investigate the fertility status of soils under Bamboo (*Bambusa vulgaris)* in Akamkpa and Odukpani Local Government Areas of Cross River State. Composite soil samples were collected at the depth of 0-15cm under Bamboo (*Bambusa vulgaris)* using soil auger from fourteen (14) locations. The soil samples were analyzed for some physico-chemical properties using standard procedures. Results obtained showed that the soils were predominantly sandy loam in both Akamkpa and Odukpani with significant difference in the soil pH which was very strongly acid (mean pH in water =5.0). Organic carbon was high (26.00 – 41.00g/kg) in Akamkpa and Odukpani (24.00 – 41.00g/kg). Total nitrogen was medium (2.4 – 4.9g/kg) in Akamkpa and low to medium (0.19 – 0.33%) in Odukpani. Available phosphorus was generally low (1.8 - 2.9mg/kg) and (1.88 – 6.63mg/kg) in both areas. Exchangeable calcium was low to medium (3.6 - 7.4cmol/kg) in Akamkpa and medium to high (5.6 - 14.8cmol/kg) in Odukpani. Magnesium contents were low (0.8-6.7cmol/kg) and high (0.4 – 12.4cmol/kg) in both areas. While exchangeable potassium (0.08 – 0.13cmol/kg) and (0.09 – 0.13cmol/kg) with sodium contents (0.06 – 0.08cmol/kg) and (0.06 – 0.10cmol/kg) were low. Exchangeable acidity of hydrogen (0.1 – 3.7cmol/kg) was high in Akamkpa and low to medium (0.08-2.32cmol/kg) in Odukpani and that of Aluminum contents (0.3 – 4.0cmol/kg) and (0.0 – 4.0cmol/kg) were generally low. The cation exchange capacity (CEC) was low (4.5 – 11.4cmol/kg) in Akamkpa and low to medium (7.2 – 24.01cmol/kg) in Odukpani and those of Effective Cation Exchange Capacity (ECEC) was low to medium (9.2 – 15.9cmol/kg) in Akamkpa but low and high (7.8 – 24.41cmol/kg) in Odukpani . The Base Saturation was medium to high (37 – 96%) in Akamkpa and high (60.9 – 98.4%) in Odukpani. The studies revealed that soils under Bamboo had high organic matter content. This could be attributed to the bamboo leaf fall which enhances the increase of organic matter content.

Keywords: Fertility status, Bamboo, Composite soil sample, physicochemical properties

INTRODUCTION

Bambusa vulgaris, common bamboo, local names; *Basini, Bans, Bakai (Bengal)* is a species of the large genus *Bambusa* of the clumping bamboo tribe *Bambuseae,* which are found largely in tropical and subtropical areas of Asia, especially in the wet tropics including the Central India and North East but highly concentrated in the Indo-Malayan rainforest. The findings of Crosby and Magill (2006) showed that bamboo has about 45 genera and about 480 species of perennial, woody, usually shrubby or treelike plants of the grass family *Poaceae*. The origin of bamboo is traced to China and India as the two largest producer of bamboo in the World. Bamboo Major Production States in India are North Eastern States of India (Rao, *et al.,* 1998). It is believed to have been introduced to Hawaii in the time of Captain James Cook in the late 18th century and it is the most popular ornamental plant there (Whistler, 2000).

Bamboos occur mostly in tropical and subtropical areas, from sea level to snow-capped mountain peaks, with a few species reaching into temperate areas. They are most abundant in Southern eastern Asia (Satya *et al.*, 2010). The plants range from stiff reeds about 1m tall to giants reaching 50m in height and 30cm in diameter near the base. Most bamboos are erect, but some are vinyl, producing impenetrable thickets in some areas. The internodal regions of the stem are usually hollow and the vascular bundles in the cross section are scattered throughout the stem. They are the fastest growing plants in the World (Saha and Howe, 2001).

Findings of Saha and Howe, (2001) have shown that bamboos have notable economic and cultural significance in South Asia, Southeast Asia and East Asia, being used for building materials, as a food source and as a versatile raw product. In the tropics they are used for constructing houses, rafts, bridges, and scaffolding. Split and flattened culms can be used as flooring and interwoven to make baskets, mats, hats, fish traps, and other articles; culms of large species may be used as containers for liquids. Paper is made from bamboo pulp, and fishing rods, water pipes, musical instruments, and chopsticks from other parts. Many bamboos are planted as ornamentals, and young shoots are eaten as a vegetable.

Bamboo can be powerfully use for land restoration (Hans, 2014). This strategic resource thrives on problem soils and steep slopes, helps to conserve soil and water, and improves land quality. It is used to restore or reclaim degraded lands, improve environment, carry out drought proofing. It grows rapidly, slowly degradation and repairing damaged ecosystems and its long fibrous and shallow roots effectively stabilize soil – a bamboo plant typically binds up to $6cm^3$ of soil, and its efficiency as a soil binder has been reported in China, Costa Rica, India, Nepal, the Philippines, and Puerto.

Bamboos are source of organic matter in the soils. They provide the soils with organic matter thus improve the soil fertility. This contributes to nutrient cycling processes and various aspect of soil fertility. Studies also showed that bamboo helps to boost nutrients and organic matter, increase carbon content, and add humus to soil through leaf fall. Bamboo in the soil absorbs and holds excessive moisture which gets released back into the soil providing better aeration for grass, plants and vegetables.

Findings of Winsley (2007), Gaunt and Lehmann (2008) has also shown that bamboo charcoal known as biochar acts as a catalyst to enhance the plants ability to absorb or retain nutrients, fosters the development of beneficial microorganisms, store and utilize carbon to assist in plant development. Soil improved by biochar is more efficient, retaining critical nutrients such as Magnesium, Calcium, Phosphorus and Nitrogen. Bamboo charcoal when submerged in water, softens the water, absorbs harmful minerals including Chlorine and releases its nutrient minerals such as Calcium, Sodium, and Magnesium into the water. Findings of Qian *et al.* (2015) have shown that this carbon rich material, known as biochar, has helped crop to thrive, possibly even increasing their yield, acid soil remediation because of its alkaline pH value and being rich in plant nutrients.

Bamboo requires well drained soils with pH range of 4.5 to 6.0. The ideal soil is sandy loam or loam. The findings of Hans (2014) has shown that it adapt to most climatic conditions and soil types, acting as a soil stabilizer**.** A sandy loam is fairly satisfactory for bamboo growth, but clayey loam produces the best quality. The findings of Christine *et al.,* (1992) showed that it grow on marginal and degraded land, elevated ground, along field bunds and river banks.

Hypothesis

This study formulates the null hypothesis (H_O) that there was no significant difference on the fertility status of the two locations.

MATERIALS AND METHODS

The Study Area

The study was conducted in Akamkpa and Odukpani Local Government Areas of Cross River State of Nigeria. Odukpani is located on Latitude 5^0 7' ' 0'N and Longitude $8^0$20' 0" E and Akamkpa is located on Latitude 8^0 7'' N and Longitude $9^0$1'' E. The both areas are situated within the coastal plains of Cross River State. The climate of the study areas were characterized by high relative humidity and rainfall. Rainfall is usually heavy occurring almost all the months of the year. The total annual rainfall is about 4,000mm and the relative humidity of 80% with an annual temperature of 29^0C (Iwena, 2008). The rainfall spreads between April and October and characterized by two peak periods and a short break in the month of August known as 'August break'.

Field and Laboratory Studies

Sample Collection and Handling

Soil samples were collected to the depth of 0-15cm under Bamboo (Bambusa vulgaris) using soil auger from fourteen locations: Awi, Okomita, Ifunkpa, Uyanga, Mbarokom, Old Netim and Ekang in Akamkpa Local Government Area and Okurikan, Akanobio, Oduyama, Obot Yoho, Okoyong, Federal Housing and Netim in Odukpani Local Government Area in the month of December, 2015. Composite samples were collected from each location and stored in a well labeled polythene bag and transported to the Soil Science laboratory, University of Calabar for analysis. In the laboratory, the samples were air dried and then ground using a porcelain pestle and mortar and sieved through a 2mm mesh. The fine earth fraction was used for all laboratory analyses.

Laboratory Analysis

The physical and chemical properties of the prepared soil samples were analyzed using standard procedures. Particle size distribution was determined by the hydrometer method (Bouyoucous, 1951) using sodium hexametaphosphate (calgon) as the dispersant. The percentages of sand, silt and clay were determined. The pH (in water) was determined in soil water ratio of 1:2.5 using a glass electrode pH meter. Organic carbon was determined by the dichromate wet oxidation method (Walkley and Black, 1934). Total nitrogen was determined by the Kjeldahl digestion method (Juo, 1979). Available phosphorus was determined according to the Bray-1 method (Bray and Kurtz, 1945). Exchangeable bases (Ca, Mg, K and Na) were extracted in 1 N NH_4OAc at pH 7. Potassium and sodium were determined with a flame photometer while calcium and magnesium were determined by the EDTA titration method (Black *et al.,* 1965). Exchangeable acidity was determined by titration method using 1 N KCL extract (McLean, 1965). Cation Exchange Capacity (CEC) was by summation of exchangeable bases while effective cation exchange capacity (ECEC) was a summation of exchangeable bases (Ca, Mg, K and Na) and exchangeable acidity. Percent base saturation was obtained by dividing the total exchangeable bases (Ca, Mg, K and Na) by the effective cation exchange capacity.

Data Analyses

Data obtained were subjected to t-test and simple descriptive statistics of range, mean, Standard deviation and variation and the use of coefficient of variation.

RESULTS AND DISCUSSION

Table 1: Physico-chemical properties of soils under Bamboo in Akamkpa Local Govt. Areas

										Exchangeable Bases				Ex. Acidity				
Location	Depth	Clay	Silt	Sand	TC	pH	Org. C.	TN	Av. P	Ca	Mg	K	Na	Al	H	CEC	ECEC	BS
	(cm)	(%)	(%)	(%)			g/kg	g/kg	mg/kg	←		cmol/kg	→					(%)
Awi	0-15	9.7	21	69.3	SL	4.9	31	4.9	2.5	3.6	0.8	0.08	0.06	3.88	3.72	4.54	12.14	37.4
Okomita	0-15	20.7	37	42.3	L	4.9	32	2.8	2.8	5.8	5.4	0.09	0.07	0.31	0.12	11.36	11.79	96.4
Ifunkpa	0-15	14.6	31	54.4	L	5.0	41	3.4	1.8	7.4	3.8	0.11	0.08	0.32	0.56	11.39	12.27	92.8
Uyanga	0-15	9.9	20	70.1	SL	5.2	39	4.9	2.4	6.2	3.9	0.08	0.06	0.33	1.9	10.24	12.47	82.1
Mbarakom	0-15	31.7	18	50.3	SCL	4.8	34	3.0	2.2	5.8	3.0	0.1	0.06	4.0	2.9	8.96	15.86	56.5
Old Netim	0-15	8.9	32	59.1	SL	4.9	26	2.4	2.1	6.6	1.8	0.13	0.07	0.3	0.4	8.5	9.2	92.4
Ekang	0-15	5.8	30	64.2	SL	5.1	28	2.9	2.9	3.7	6.7	0.11	0.06	0.53	0.2	10.57	11.3	93.5
Mean		14.5	27	58.5		5.0	33	3.0	2.4	5.6	3.6	0.1	0.07	1.4	1.4	9.37	12.1	78.7
Minimum		5.8	18	42.3		4.8	26	2.4	1.8	3.6	0.8	0.08	0.06	0.3	0.1	4.5	9.2	37
Maximum		31.7	37	70.1		5.2	41	4.9	2.9	7.4	6.7	0.13	0.08	4.0	3.7	11.4	15.9	96
St. Dev.		9.00	7.26	10.25		0.14	5.5	1.0	0.39	1.43	2.02	0.02	0.008	1.75	1.45	2.40	1.98	22.8
CV (%)		62.1	26.9	17.5		2.8	167	333	16.3	25.5	56.1	20	11.3	125	103.6	25.6	16.4	29

TC =Textural Class, Org. C = Organic Carbon, TN =Total Nitrogen, Av. P = Available Phosphorus, Ca = Calcium, Mg = Magnesium, K = Potassium, Al = Aluminium, H = Hydrogen, CEC = cation exchange capacity, ECEC = Effective Cation Exchange Capacity, BS = Base Saturation, L = Loam, SL = Sandy Loam, L = Loam, SCL = Sandy Clay Loam, CV = Coefficient of Variation

Table 2: Physico-chemical properties of soils under Bamboo in Odukpani Local Government Areas

										Exchangeable Bases				Ex. Acidity				
Location	Depth (cm)	Clay (%)	Silt (%)	Sand (%)	TC	pH	Org. C. g/kg	TN g/kg	Av. P mg/kg	Ca ←	Mg	K	Na Cmol/kg	Al	H	CEC	ECEC →	BS (%)
Okurikan	0-15	8.7	31	60.3	SL	5.4	26	2.2	1.88	6.6	0.4	0.11	0.9	0.0	0.6	7.2	7.8	92.3
Akanobio	0-15	10.7	25	64.3	SL	5.0	25	2.8	2.25	5.8	3.0	0.1	0.07	3.84	1.92	8.97	14.73	60.9
Oduyama	0-15	7.7	23	69.3	SL	4.95	39	3.0	2.5	7.6	3.8	0.12	0.09	4.0	2.32	11.61	17.93	64.8
Obot Yoho	0-15	11.7	34	54.3	SL	4.85	34	2.9	2.88	14.8	5.0	0.13	1.0	0.28	0.12	20.03	20.43	98
Okoyong	0-15	5.7	20	74.3	LS	5.0	24	1.9	6.63	5.6	1.8	0.09	0.06	0.32	0.08	7.55	7.95	94.9
F/Housing	0-15	12.7	45	42.3	L	4.95	41	3.3	2.13	11.4	12.4	0.12	0.09	0.0	0.4	24.01	24.41	98.4
Netim	0-15	6.7	31	62.3	SL	5.1	31	2.4	2.13	6.8	5.8	0.11	0.08	0.0	0.56	12.79	13.35	95.8
Mean		9.1	29.9	61.0		5.0	31	3.0	2.9	8.4	4.6	0.1	0.3	1.2	0.9	13.2	15.2	86.4
Minimum		5.7	20	42.3		4.85	24	1.9	1.88	5.6	0.4	0.09	0.06	0.0	0.08	7.2	7.8	60.9
Maximum		12.7	45	74.3		5.4	41	3.3	6.63	14.8	12.4	0.13	1.0	4.0	2.32	24.01	24.41	98.4
St. Dev.		2.6	8.3	10.4		0.18	6.9	0.49	1.67	3.44	3.9	0.013	0.43	1.86	0.89	6.48	6.20	16.3
CV (%)		28.6	27.8	17		3.6	223	163	57.6	40.9	84.8	13	143.3	155	98.9	49.1	40.9	18.9

TC =Textural Class, Org. C = Organic Carbon, TN =Total Nitrogen, Av. P = Available Phosphorus, Ca = Calcium, Mg = Magnesium, K = Potassium, Al = Aluminium, H = Hydrogen, CEC = cation exchange capacity, ECEC = Effective Cation Exchange Capacity, BS = Base Saturation, L = Loam, SL = Sandy Loam, L = Loam, SCL = Sandy Clay Loam, CV = Coefficient of Variation

Table 3: t-test at 0.05% significance level of physicochemical properties of soils in the study area

Soil properties	Mean diff.	t-test	diff.	Sig at 0.05%
Sand	-104.4	-3.006	13	*
Silt	- 60	-2.819	13	*
Clay	-112.7	-13.73	13	*
Ph	-1.25	-2.144	13	**
Org. C	-4.7	-2.710	13	*
Total N	-7.5	-2.387	13	*
Avail. P	-7.58	-1.744	13	**
Ca	-19.9	-2.051	13	**
Mg	-7.06	-0.6258	13	**
K	-0.12	-1.991	13	**
Na	1.02	1.091	13	**
H	-11.64	-2.670	13	*
CEC	-34.2	-1.996	13	**
ECEC	-46.27	-0.7507	13	**
BS	-181	-2.603	13	*

* = significantly different, ** = no significantly different

TABLE 4: FERTILITY CLASSES FOR RATING SOIL CHEMICAL PROPERTIES

Parameter	Low	Medium	High
Total N (%)	0.1 - 0.2	0.2 - 0.5	0.5-1.0
Bray 1 - P(mg/kg)	< 8.0	8 -20	> 20
Exchangeable K^{+} (cmol/kg)	0.2	0.2 - 0.4	>0.40
Exchangeable Ca^{2+} (cmol/kg)	< 5.0	5.0 – 10	> 10.0
Exchangeable Mg^{2+} (cmol/kg)	< 1.5	1.5 - 3.0	3.0
Exchangeable Na^{+} (cmol/kg)	< 0.3	0.3 - 0.7	0.7
Soil pH $_{1:2.5}$	< 5.5	5.5 - 7.0	7.0 - 8.5
Aluminium Sat. (%)	< 30	30 – 60	> 60
Exchangeable Al (cmol/kg)	< 4.0	-	> 4.0
Base Sat. (%)	< 20	20 – 60	> 60
CEC (cmol/kg)	5 – 15	15 – 25	25 – 40
ECEC (cmol/kg)	< 10.0	10 – 20	> 20
Org. Carbon (%)	< 1.5	1.5 - 2.0	> 2.0

SOURCE: FDALR (1990) and Landon(1991)

TABLE 5: Soil pH Rating

Soil pH Range	Rating
< 4.5	Extremely acid
4.5 - 5.0	Very strongly acid
5.1 - 5.5	Strongly acid
5.6 - 6.0	Moderately acid
6.1 - 6.5	Slightly acid
6.6 - 7.5	Neutral
7.6 - 7.8	Slightly alkaline
7.9 - 8.4	Moderately alkaline
8.5 - 9.0	Strongly alkaline
> 9.0	Very strongly alkaline

SOURCE: FAO (2004). Special programme for Food security, Federal Ministry of Agriculture and Rural Development (SPFS FMARD)

Soil texture

The particle size analysis is presented in Table 1 and 2. The results shows that the soils are coarse textured with a high content of sand giving dominant textural classes of sandy loam and t – test result showed that all the texture were significantly different ($p<0.05$). The high sand content shows that the proportion of sand was higher than silt and clay. This means the soil is low in water holding capacity and can retain low nutrients than silt and clay that have greater capacities to retain water and available nutrients. This agrees with the work of Akpan – Idiok *et al.* (2012) who reported that coarse texture soils at the surface to subsurface soils in the tropics are well aerated, low in nutrients, high infiltration rates and showed susceptibility to degradation. The content of clay was high in coefficient of variability to those of sand and silt. The high variability of clay in the location implied differences in influence of clay on soil properties such as moisture nutrient retention, cation exchange capacity (CEC) and vis-à-vis soil management (Ogunkunle and Erinle, 1994).

CHEMICAL PROPERTIES

Soil pH

Result on the soil pH (H_2O) is presented in Table 1 and 2. The soil pH (H_2O) showed very strongly acid (FAO, 2004) and t – test result showed that there was no significantly different (p<0.05). The content of the soil pH was low in coefficient of variability. This might be attributed to the acidic nature of the parent rock and intensive rainfall releasing H^+ which contributes to the acidity of the soil. This agrees with the work of (Ogban *et al.*1998 and Akpan- Idiok *et al.* 2012) who reported that soil pH ranged from 4.9-5.2 is due to the acidic conditions of soils resulting from high rainfall exceeding 3500mm which could leach out basic cations from the soil solum in the area.

Organic Carbon

The Organic Carbon is presented in Table 1 and 2. The organic carbon was high as reported by FDALR (1990) and Landon (1991) and t – test result showed that there was significantly different (p<0.05).The content of organic carbon varied highly in its coefficient of variability. The high level in the organic carbon could be attributed to the slow decomposition of bamboo leaves in the environment which depend on the carbon/nitrogen ratio to mediate microbes at different rates in the complex mixture of chemical compounds. This is in line with the work of Agbede, (2009) who reported that the lower the nitrogen the higher the carbon/nitrogen ratio which slower the rate of decomposition. Agbede (2009) gave the carbon: nitrogen ratio for tropical soil organic matter as 10:15:1.

Total nitrogen

The total nitrogen is presented in Table 1 and 2. The total nitrogen was generally low as reported by FDALR (1990) and Landon (1991) and t – test result showed that there was significantly different (p<0.05). The content of total nitrogen varied highly in its coefficient of variability. This variation occur due to the low in the nitrogen content resulting from change of N_2 gas to plant utilization forms by mineralization since organic N is converted to usable mineral N, a major source in non- fertilized soils (Agbede, 2009). Generally, tropical soils usually have low nitrogen (Ojo – Atere *et al.,* 2011). This agrees with Ibanga *et al.* (2008) who stated in Calabar that a mean value of 0.4g/kg total nitrogen is low in Calabar environment.

Available phosphorus

The available Phosphorus is presented in Table 1 and 2. The available Phosphorus was generally low as reported by FDALR (1990) and Landon (1991) and t – test result showed that there was no significantly different (p>0.05). The content of available phosphorus varied highly in its coefficient of variability. The high coefficient of variability shows low phosphorus content which could be attributed to soil erosion that contributes to loss of phosphorus and acidic nature of the soil hence makes phosphorus gets tied up with iron and aluminum. This agrees with (Ogban *et al*. 1998; Chikezie *et al.* 2010 and Ojo – Atere *et al*. 2011) who stated that highly weathered soils of the tropics are generally deficient and low in available phosphorus.

Exchangeable Bases

Calcium

The exchangeable calcium is presented in Table 1 and 2. The exchangeable calcium was low, medium and high as reported by FDALR (1990) and Landon (1991) and t – test result showed that there was no significantly different ($p>0.05$). The content of exchangeable calcium varied highly in its coefficient of variability. This could be due to low exchangeable bases and acidity clays. This is in line with Ojo – Atere *et al.* (2011) who observed that the deficiencies of calcium usually occur in very acidic sandy soils with low cation exchange capacity in the tropics.

Magnesium

The exchangeable magnesium is presented in Table 1 and 2. The exchangeable magnesium was low, medium and high as reported by FDALR (1990) and Landon (1991) and t – test result showed that there was no significantly different ($p>0.05$). The content of exchangeable magnesium varied highly in its coefficient of variability. This high coefficient of variability shows that exchangeable magnesium was low. This agrees with Bulktrade (1989) that reported that magnesium content of South Eastern soils are low to medium in surface and sub – surface soils.

Potassium

The exchangeable potassium is presented in Table 1 and 2. The exchangeable potassium was generally low as reported by FDALR (1990) and Landon (1991) and t – test result showed that there was no significantly different ($p>0.05$). The content of exchangeable potassium varied highly in its coefficient of variability. The low in potassium is due to low cation exchange and high rainfall causing weathering in the areas. This is in line with the work of Ojo – Atere *et al.* (2011) who reported that the soil potassium (K) status in the tropics is related to the parent material and the degree of weathering.

Sodium

The exchangeable sodium is presented in Table 1 and 2. The exchangeable sodium was generally low as reported by FDALR (1990) and Landon (1991) and t – test result showed that there was no significantly different ($p>0.05$). The content of exchangeable sodium varied highly in its coefficient of variability. This high coefficient of variability shows the leaching condition of this cation.

Exchangeable Acidity

Hydrogen

The exchangeable Hydrogen is presented in Table 1 and 2. The exchangeable hydrogen was generally low as reported by FDALR (1990) and Landon (1991) and t – test result showed that there was significantly different ($p<0.05$). The content of exchangeable hydrogen varied highly in its coefficient of variability. This high coefficient of variability shows low hydrogen attributed to the high rainfall in the areas resulting in leaching most of the nutrients down the soil profile.

Cation Exchange Capacity

The cation exchange capacity (CEC) is presented in Table 1 and 2. The results show that the cation exchange capacity (CEC) varied from low to medium as reported by FDALR (1990) and Landon (1991) and t – test result showed that there was no significantly different ($p>0.05$). The content of cation exchangeable capacity was low in its coefficient of variability. The variation might be attributed to the Organic carbon content of the soil properties. The more the organic matter (humus) content of the soil, the higher, the CEC and has greater potential ability for soil fertility (Peinemann *et al.* 2002). It is also reported in the Clemson University (2015) that a typical CEC for soils is about 2.0meq/100g of soil. This gives an indication of the soils potential to hold plant nutrients.

Effective Cation Exchange Capacity

The ECEC is presented in Table 1 and 2. The results show that the ECEC was low, medium and high as reported by FDALR (1990) and Landon (1991) and t – test result showed that there was no significantly different ($p<0.05$). The content of effective cation exchange capacity was low in its coefficient of variability. Low ECEC has been attributed to strongly weathered soils. Agbede (2009) reported tropical soils have low ECEC and SOM is the major source of ECEC in such soils with higher values in the top soils than the sub soils. The higher the ECEC, the more cationic nutrients the soil can retain against leaching forces. Bulktrade (1989) reported ECEC range of 2.0-28.4cmol/kg for surface soils in Southeastern Nigeria to be medium and high.

Base Saturation

The Base Saturation is presented in Table 1 and 2. The Base saturation was generally high as reported by FDALR (1990) and Landon (1991) and t – test result showed that there was significantly different ($p<0.05$). The content of Base saturation was low in its coefficient of variability. This indicates the base-rich nature of the soils of the study area. The high level BS was related to the soil pH range and the level of the basic cations of the soils.

CONCLUSIONS/RECOMMENDATIONS

The result of the study affirmed that the soils were predominantly sandy loam in physical properties and low to medium in chemical properties with the exception of organic carbon which was high in fertility characteristics. Based on this study, the two research areas does not have different management practices, hence recommends that production of Bamboo should be promoted to improve soil nutrient situation due to high organic carbon content and sometimes bamboo may get over its acidity naturally.

REFERENCES:

Agbede, O. O. (2009). Understanding soil and plant nutrition. Petra Digital Press. ISBN: 978-978-900-087-6, Pp 53157

Akpan – Idiok, A.U. (2012). Physicochemical Properties, Degradation Rate and Vulnerability Potential of soils formed on Coastal plain sands in Southeast, Nigeria. *International Journal of Agricultural Research, 7*:358 –366

Black, C. A., Evans, D. D., White, J. L., Ensminger, L. E. and Clerk, F. E. (1965). Methods of Soil Analysis. American Society of Agronomy. Inc., Madison, WI., USA

Bouyoucos, C. A. (1951). A re-calibration of the hydrometer for making mechanical analysis of soils. Agron. J., 31:510-513

Bray, R. H. and Kurtz, L. T. (1945). Determination of total, organic and available forms of phosphorus in soils. Soils Sci., 59: 39-46 Retrieved from Scialert. Net/fulltext/%3Fdoi%3Dijar....

Bulktrade and Investment Co Ltd (1989). Soil and land use survey of Cross River State Ministry of Agriculture and Natural Resources, Calabar

Chikezie, I.A. I.A., H. Eswaran, D.O. Asawalam and A.O. Ano, (2010). Chracterization of two benchmark soils of contrasting parent materials in Abia state, Southeastern Nigeria. Global J. pure Applied Sci., 16: 23-29.

Christine, R., Max, F. W. and David, C. (1992). Timber press Bamboos in Europe.

Clemson Public Service Activities (2015). Agricultural service Laboratory, Clemson University, 130 Lehotsky Hall, Clemson

Crosby, M. R. and Magill, R. E. (2006). Index of bryophytes 2005. Missouri Botanical Garden, St. Louis, 12pp

FAO, (2004). Special Programme for Food Security, Federal Ministry of Agric. And Rural Development (SPFS FMARD)

FDALR, (1990). The reconnaissance soil survey of Nigeria (1:450,000) Soil report (Lagos, Ogun, Oyo, Ondo, Bendel States). Federal Department of Agricultural Land Resources, Lagos 1.

Hans, F. (2014). Network for Bamboo and Rattan. Retrieved from hansfriederich. Wordpress.com/2014/0…

Ibanga I. J, Umoh N. B. & Iren, O. B. (2008). Effects of Cement dust on soil chemical properties in Calabar environment. Soil and plant analysis vol 39-issue. Pp 551 - 558

Iwena, O. A. (2008). Essential of Geography for Secondary Schools 2 Pp 240-245

Juo, A.S.R. (1979). Selected Methods for soil and plant Analysis. *International Institute of Tropical Agriculture* (IITA), Ibadan, Nigeria. Retrieved from Scialert. Net/fulltext/%3Fdoi%3Dijar...

Landon, J. R. (1991). Booker Tropical Soil Manual. Longman Publishers, Harlow, UK. Page 134

Lehmann, J. and Andrew C. D. (2013). Heterogenous global crop yield response to biochar: a meta – regression analysis. Published 16 December, 2013. Top publishing Limited. Retrieved from edepot.wur.nl/311299

McLean. E. O. (1965). Aluminium In:Methods of soil Analysis, Part 2: Chemical and Biological Properties, Black, C. A. (Ed.). American Society of Agronomy, Madison, WI, USA, pp: 987- 990. Retrieved from Scialert. Net/fulltext/%3Fdoi%3Dijar...

Ogban, P.I, T.P. Ekanem, E.R. Etim and G.S Effiong, (1998). Muching Practices on a tropical physical properties. Proceedings of the 25th Annual Conference on soil Science Society of Nigeria, September 10, 1998, Abeokuta, Nigeria.

Ogunkunle, A. O. & Erinle, W. O. (1994). Influence of tillage on the variability of some properties of an Alfisol in Southern Nigeria. Journal of Science Research 1(1):52-57

Ojo-Atere, J. O., Ogunwale, J. A. & Oluwatosin, G. A. (2011). Fundamentals of Tropical Soil Science. Evans Brothers(Nigeria Publishers) Ltd. ISBN 978-978-020-976-6, Pp 101, 260, 261 & 262

Peinemann, N., Amiotti, N. M, Zaiba, P, and Villamil, M. B. (2002). "Effect of clay minerals and organic matter on the Cation exchange capacity of silt fraction" J Plant Nutrition, 163(1), 2000 Pp 47-52

Qian, K. Z., Kumar, A., Zhang, H. L., Bellmer, D., and Huhnke, R. (2015)."Recent advances in utilization of biochar", Renewable and Sustainable Energy Reviews 42,1055-1064. DOI: 10.1016/j rser:2014:10.074

Rao, A.N., Ramanatha, R. V. and John, D. (1998). Priority species of bamboo and rattan, page 25, Bioversity International, ISBN 978-92-9043-491-7. Retrieved from www.bamboobotanicals.ca/html/bamboo...

Saha, S. and Howe, H. F. (2001). The Bamboo Fire Cycle Hypothesis: A comment. The American Naturalist 6(158): 659-663

Satya, S., Bal, L.M. Singhal, P. and Naik, S. N. (2010). Bamboo shoot processing. Food quality and safety aspect (a review). Trends Food (Issue 21), Pages 181 – 189.

Walkley, A. and Black, I. A. (1934). An examination of the degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci., 37:29-38

Whistler, W. A. (2000). Tropical ornamentals: a guide, Pp 77-78, Timber Press 2000

Winsley, P. (2007), Guant, J. and Lehmann, J. (2008). "Energy and Emissions Associated with Biochar Sequestration and pyrolysis Bioenergy production" . Environmental Sciences and Technologies. 42 (11): 4152