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

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 no significant difference in the soil pH which was very strongly acid (mean pH in water =5.0). Organic carbon was high (2.6 - 4.1%) in Akamkpa and Odukpani (2.4 – 4.1%). Total nitrogen was medium (0.24 - 0.49%) 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 while the Base Saturation was medium to high (37 – 96%) in Akamkpa and high (60.9 – 98.4%) in Odukpani. The studies revealed that the soils under Bamboo had high organic matter content. This can be attributed to conducive environment around bamboo trees which enhance the production of humus.

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

INTRODUCTION

The word Bamboo (English,) comes from the Kannada term bambu which was introduced to English through Indonesian and Malay (Satya *et al.,* 2010). Bamboo is known as Banas (Hindi), Veduru (Telugu), Moongil (Tamil), Mulankoombu (Malayalam), Bansberankur (Bengali), Kalkipan (Marathi), Baunsagaja (Oriya), and Baans (Urdu & Punjabi).

Its origin is traced to China and India as the second largest producer of bamboo in the World. It is widely cultivated in East, Southeast and South Asia, as well as tropical Africa including Madagascar. The areas particularly rich in bamboo are the North Eastern States, the Western Ghats, Chattisgarh, and Andaman Nicobar Islands. 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).

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*. 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, with some species in the Americas and Africa and none in Australia. 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 instead of in a cylindrical arrangement. They are the fastest growing plants in the World (Saha and Howe, 2001). The bamboos contains three clades classified as tribes, and these strongly correspond with geographic divisions, representing the New World herbaceous species (Olyreae), tropical woody bamboos (Bambuseae), and temperate woody bamboos (Arundinarieae).

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. It was also stated in the findings of Satya *et al.,* (2010) that, *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. *Bambuseae* is a group of perennial evergreens in subfamily *Bambusoideae*, characterized by having three stigmata and tree like behavior, that are in turn of the true grass family *poaceae.* There are 91 genera and over 10,000 species. The important genera are *Arudinaria, Bambusa, Cephalostachyum, Dendrocalamus, Ochlandra, Oxytenanthera, Phyllostachys, Pseudostachyum* etc. The size of bamboo varies from small annuals to giant timber bamboo (Watson and Dallwitz, 2008). Sixteen (16) commercially significant species include *Bambusa balcooa, Bambusa bambos, Bambusa nutans, Bambusa pallida, Bambusa polymorpha, Bambusa tuda, Bambusa vulgaris, Dendrocalamus brandisii, Dendrocalamus giganteus, Dendrocalamus hamiltonii, Dendrocalamus strictus, Oxytenanthera stocksii, Melocanna bambusoides, Ochlandra travancorica, Schizostachyum dullooa and Thyrsostachys oliveri* (Maxim *et al.,* 2007).

Bamboos are among the plants most widely used by humans. 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, conserve soil, 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. In short, bamboo offers hope and a new lease of life in areas that continue to suffer from severe land degradation – that's one quarter of the World's land surface, according to the UN's Food and Agriculture Organization (U. S. Environmental Protection Agency, 2009) and huge swathes of deforested lands: the World Resource Institute (WRI) and the International Union for the Conservation of Nation (IUCN) in 2014 estimates that 30 percent of global forest cover has been completely cleared and a further 20 percent degraded over the last century (Hans, 2014).

Bamboo is a preferred species for erosion control. They are planted as a measure for erosion control and as buffer against wave action. The rapid growth and the strong root system make bamboo particularly suited for soil protection. It was reported that a single bamboo plant can bind up to 6m^3 of soil and research in China showed that soil erosion in a bamboo plantation is 4.7 times lower than in adjacent sweet potato cropland (Hans, 2014).

Bamboos are source of organic matter in the soils. They provide the soils with organic matter thus improve the soil fertility. Findings have shown that an area planted with bamboo when removed appears to be more fertile than areas where bamboos were not planted. This contributes to nutrient cycling processes and various aspect of soil fertility. Studies also showed that bamboo helps to conserve water, boost nutrients and organic matter, increase carbon content, and add humus to soil through leaf fall.

Bamboo absorbs harmful minerals including Chlorine and releases its nutrient minerals such as Calcium, Sodium, and Magnesium. Bamboo in the soil absorbs and holds excessive moisture. This moisture 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. Additionally, nutrients present in the soil are more available to plants, making good soil even better.

Findings of Ruttanavut *et al.,* (2009) have shown that this carbon rich material, known as biochar, has helped the crop to thrive, possibly even increasing their yield.

A Meta – analysis found by Lehman and Andrew Crane – Droesch, (2013) at the University of California, Berkeley showed that an overall average yield increase of 10% rising to 14% in acidic soils. Biochar's greatest potential might be in places where soils are degraded and fertilizer scarce, in part because it helps the soil to better retain nutrients that it does not have. They also showed that preliminary data suggest that farms using biochar averaged 32% higher yields than control.

Studies have also shown that bamboos enhance soil biological properties. They harbor soil microorganisms such as ants, eelworms, millipedes, etc. The findings of Chang *et al,* (2016) has also shown that the populations of bacteria, fungi and antinomycetes were considerably higher in the bamboo plots than in the barren land and that the amount of microorganisms was higher in the bamboo forests than in the barren land, which suggest that a higher abundance of microbes is important factor determining the structure of microbial communities in forest soils.

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

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 standardized with buffer solutions 4.0 and 6.85. 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 extracted using the Bray-1 method (Bray and Kurtz, 1945) and determined calorimetrically with a spectrophotometer. 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 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

The data obtained were subjected to simple descriptive statistics using the range, mean and Standard deviation including 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 (cm)	Clay (%)	Silt (%)	Sand (%)	TC	pH	Org. C. (%)	TN (%)	Av. P mg/kg	Ca ←	Mg	K cmol/kg	Na →	Al	H	CEC	ECEC	BS (%)
Awi	0-15	9.7	21	69.3	SL	4.9	3.1	0.49	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	3.2	0.28	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	4.1	0.34	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	3.9	0.49	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	3.4	0.3	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	2.6	0.24	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	2.8	0.29	2.9	3.7	6.7	0.11	0.06	0.53	0.2	10.57	11.3	93.5
Total		101	189	410		34.8	23.1	2.43	16.7	39.1	25.4	0.7	0.46	9.67	9.8	65.6	85.0	551
Mean		14.5	27	58.5		5.0	3.3	0.3	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	2.6	0.24	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	4.1	0.49	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	0.55	0.10	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	16.7	33.3	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, PBS – Percent 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. (%)	TN (%)	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	2.6	0.22	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	2.5	0.28	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	3.9	0.3	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	3.4	0.29	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	2.4	0.19	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	4.1	0.33	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	3.1	0.24	2.13	6.8	5.8	0.11	0.08	0.0	0.56	12.79	13.35	95.8
Total		64	209	427		35	22	2.0	20	59	32	1.0	2.0	8.0	6.0	92.0	107	605
Mean		9.1	29.9	61.0		5.0	3.1	0.3	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	2.4	0.19	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	4.1	0.33	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	0.69	0.049	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	22.3	16.3	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, PBS – Percent Base Saturation, L – Loam, SL – Sandy Loam, L – Loam, SCL – Sandy Clay Loam, CV – Coefficient of Variation.

Soil texture

From table 1 & 2, sand ranged from 42.3 – 70.1% and 42.3 – 74.3% with a mean value of 58.5% in Akamkpa and 61.0% in Odukpani. Silt ranged from 18 – 37% and 20 – 45% with a mean value of 27% in Akamkpa and 29.9% in Odukpani. While clay ranged from 5.8 – 31.7% and 5.7 – 12.7% with a mean value of 14.5% in Akamkpa and 9.1% in Odukpani. The Coefficient of Variation of 17.5% sand, 26.9% silt, 62.1% clay in (table 1) and 17% sand, 27.8% silt, 28.6% clay (table 2) compared to their mean values were high. This shows that the soils are coarse textured with a high content of sand giving dominant textural classes of sandy loam.

CHEMICAL PROPERTIES

FDALR (1990) and Landon (1991) of rating fertility classes were used for these chemical properties.

Soil pH

From table 1 & 2, the soil pH (H_2O) ranged from 4.8 – 5.2 in Akamkpa with the mean value of 5.0 and 4.85 – 5.4 in Odukpani with a mean value of 5.036 indicating that the soil was very strongly acidic (FAO, 2004). Their coefficient of variations 2.8% and 3.6% in (table 1 & 2) compared with their soil pH mean values (5.0 and 5.036) was low.

Organic Carbon

From table 1 & 2, Soil Organic Carbon ranged from 2.6 – 4.1% in Akamkpa with a mean value of 3.3% and 2.4 – 4.1% in Odukpani with a mean value of 3.1%. This shows that the organic matter content was high. According to FDALR (1990) and Landon (1991) of rating fertility classes, above 2.0% is considered high. Their coefficient of variations 16.7% and 22.3% in (table 1 & 2) compared with their mean values 3.3% and 3.1% was high. The high level in the organic carbon can be attributed to the high decomposition of bamboo leaves in the environment which helps to mediate microbes at different rates hence play an important role in the complex mixture of chemical compounds. Such levels of organic carbon can sustain intensive cropping (Akpan – Idiok, 2012).

Total nitrogen

From table 1 & 2, the Total Nitrogen ranged from 0.24 – 0.49% in Akamkpa with a mean value of 0.3% and 0.19 – 0.33% in Odukpani with a mean value of 0.264%. This shows that the total nitrogen was low. Between 0.1 – 0.2% is low according to the rating. The low nitrogen in the areas results 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). Their coefficient of variations 33.3% and 18.9% in (table 1 & 2) compared with their mean values 0.3% and 2.9% was high.

Available phosphorus

From table 1 & 2, Available phosphorus ranged from 1.8 – 2.9mg/kg in Akamkpa with a mean value of 2.4mg/kg and 1.88 – 6.63mg/kg in Odukpani with a mean value of 2.9mg/kg. According to the rating, the available Phosphorus was generally low in the areas. Less than 8.0mg/kg is rated low. The low phosphorus can be attributed to the nature of plant residues, parent material and degree of weathering. Their coefficient of variations 16.3% and 41.1% in (table 1 & 2) compared with their mean values 2.4mg/kg and 2.9mg/kg was high.

Exchangeable Bases

Calcium

From table 1 & 2, Calcium ranged from 3.6-7.4cmol/kg in Akamkpa with a mean value of 5.6cmol/kg and 5.6 – 14.8cmol/kg in Odukpani with a mean value of 8.4cmol/kg. According to the rating, the exchangeable calcium was low, medium and high in the areas. Less than 5.0cmol/kg is low and between 5.0 –10cmol/kg is medium while above 10cmol/kg is high. Their coefficient of variations 25.5% and 84.8% in (table 1 & 2) compared with their mean values 5.6cmol/kg and 8.4cmol/kg was high.

Magnesium

From table 1 & 2, Magnesium ranged from 0.8 – 6.7cmol/kg in Akamkpa with a mean value of 3.6cmol/kg and 0.4 – 12.4cmol/kg in Odukpani with a mean value of 4.6cmol/kg. According to the rating, the exchangeable magnesium was low, medium and high in the areas. Less than 1.5cmol/kg is low and 1.5 - 3.0cmol/kg is medium while 3.0cmol/kg is high. Their coefficient of variations 56.1% and 84.8% in (table 1 & 2) compared with their mean values 3.6cmol/kg and 4.6cmol/kg was high.

Potassium

From table 1 & 2, Potassium ranged from 0.08-0.13cmol/kg in Akamkpa with a mean value of 0.12cmol/kg and 0.09-0.13cmol/kg in Odukpani with a mean value of 0.1cmol/kg. According to the rating, the exchangeable potassium was generally low in the areas. 0.2cmol/kg is low. Their coefficient of variations of 20% and 13% in (table 1 & 2) compared with their mean values of 0.12cmol/kg and 0.13cmol/kg was high.

Sodium

From table 1& 2, Sodium ranged from 0.06-0.08cmol/kg in Akamkpa with a mean value of 0.07cmol/kg and 0.06 – 1.0cmol/kg in Odukpani with a mean value of 0.1cmol/kg. According to the rating, the exchangeable sodium was generally low in the areas. Less than 0.3cmol/kg is low. Their coefficient of variations of 11.3% and 143.3% in (table 1 & 2) compared to their mean values of 0.07cmol/kg and 0.1cmol/kg was high.

Exchangeable Acidity

Hydrogen

From table 1 & 2, Hydrogen ranged from 0.1-3.7cmol/kg in Akamkpa with a mean value of 1.4cmol/kg and 0.08-2.32cmol/kg in Odukpani with a mean value of 0.9cmol/kg. According to the rating, the exchangeable Hydrogen was generally low. This is attributed to the high rainfall in the areas resulting in leaching most of the nutrients. Their coefficient of variations of 103.6% and 98.9% in (table 1 & 2) compared with their mean values of 1.4cmol/kg and 0.9cmol/kg was high.

Aluminum

From table 1 & 2, Aluminum ranged from 0.3 – 4.0cmol/kg in Akamkpa with a mean value of 1.4cmol/kg and 0.0-4.0cmol/kg in Odukpani with a mean value of 1.2cmol/kg. According to the rating, the exchangeable aluminum was low. Less than 4.0cmol/kg is rated low. Their coefficient of variations 125% and 155% in (table 1 & 2) compared with their mean values 1.4cmol/kg and 1.2cmol/kg was high.

Cation Exchange Capacity

From table 1 & 2, the Cation Exchange Capacity (CEC) ranged from 4.5-11.4cmol/kg in Akamkpa with a mean value of 9.37cmol/kg and 7.2 – 24.01cmol/kg in Odukpani with a mean value 13.2cmol/kg. According to the rating, the Cation Exchange Capacity (CEC) varied from low to medium. Between 5-15cmol/kg is low and 15-25cmol/kg is medium. This might be attributed to differences in Organic Carbon content of the soil properties. The more the organic matter (humus) content of the soil, the higher, its CEC and the greater the potential fertility of that soil (Peinemann *et al.,* 2002). Their coefficient of variations 25.6% and 49.1% in (table 1 & 2) compared with their mean values 9.37cmol/kg and 13.2cmol/kg was high.

Effective Cation Exchange Capacity

From table 1 & 2, the Effective Cation Exchange Capacity (ECEC) ranged from 9.2–15.9cmol/kg in Akamkpa with a mean value of 12.1cmol/kg and 7.8 – 24.4cmol/kg in Odukpani with a mean value of 15.2cmol/kg. According to the rating, the ECEC was low, medium and high in the areas. Less than 10.0cmol/kg is low and 10-20cmol/kg is medium while above 20cmol/kg is high. Their coefficient of variations 16.4% and 40.9% in (table 1 & 2) compared with their mean values 12.1cmol/kg and 15.2cmol/kg was high.

Base Saturation

From table 1 & 2, the Base Saturation ranged from 37 – 96% in Akamkpa with a mean value of 78.7% and 60.9 – 98.4% in Odukpani with the mean value of 86.4%. According to the rating, the Percent Base Saturation of the areas was generally high. Above 60% is high. Their coefficient of variations 29% and 18.9% in (table 1 & 2) compared with their mean values 78.9% and 86.4% was low.

CONCLUSION

In general, 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. The high organic carbon can be attributed to the high decomposition of bamboo leaves which increases the soil organic matter content. Furthermore, the results reveal that hydrogen was high in Akamkpa. This could be as a result of leaching away of the basic cations (Ca^{2+}, Mg^{2+}, K^+ , Na^+) by rainwater and replacing these basic cations by hydrogen ion, (H^+) from carbonic acid (H_2C0_3) formed from water and dissolved carbon dioxide. Cation Exchange Capacity (CEC) which is an indication of the relative ability of K, Na, Ca and Mg to displace other cations was observed to be low in Akamkpa, but low to medium in Odukpani, the low in

CEC implies low fertility of the soil. It is therefore recommended that based on the high organic carbon content, the soils can support crop production but requires some application of fertilizers to boast other nutrients which were low. More so, for the soils under bamboo to be put into use for crop production, the bamboos need to be removed by uprooting.

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