FERTILITY STATUS AND MANAGEMENT OF USSE OFFOT INLAND VALLEY SOILS FOR INCREASED CASSAVA YIELDS IN AKWA-IBOM STATE, NIGERIA

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ABSTRACT
Inland valley soils of USSE OFFOT in Akwa Ibom State, Nigeria grown to cassava were characterized with the aim of knowing their fertility indices. Soil samples were made representing the top (0-15cm) and sub soils (15-30cm) and were analyzed. The soils were characterized by strongly to moderately soil reaction (pH 4.26 5.12), low organic C (0.72 1.88%), low total N (0.13 0.19%), high available Bray -1P (73.33 93.32 mgkg^{-1}), low exchangeable Na (0.02 0.05 cmol(+) kg^{-1} and Effective Cation Exchange Capacity (ECEC). Management measures to be adopted by the farmers to raise the fertility status of the soils were suggested for increased cassava yields.

KEY WORDS: Characterization, Inland Valley Soils, cassava**,** fertility

INTRODUCTION
Cassava is the seventh most important crop of the world and contributes a staple food for an estimated 800 million people, one-eight of the world population (Nweke 1996). In Nigeria, it is the basic staple food to more than 70% of the population and about 90% of cassava produced in Nigeria is used domestically for food, animal feed, industrial pharmaceutical uses and unquantifiable quantities for export. For human consumption alone it is processed into over 50 food forms such as gari, lafun, bread, flakes, flour, etc (Eke-Okoro *et al* 2008)

Nigeria is ranked as the top producer of cassava at 45.75 million tons annually (FAO 2008). Increase in the production of cassava in Nigeria is of strategic interest to the country to cushion the effect of population pressure, enhance poverty reduction, sustainable food and nutrition security and income generation (Nkanleu and Gockowaski 2006). As the population of the country continues to grow, there is need to investigate the growing performance of the food crop, bearing in mind the cultivable agricultural land area of the country (Raemaeker 2007). Declining soil fertility in the cultivable agricultural land is the major problem militating against increase in cassava production in this country. In order to record and increased in yield, fertilizer must be applied to the soil. For fertilizer application to be effective, the type and quantity applied must depend on soil characterization, otherwise this will result to soil abuse and low yield. Hence, the objectives of this work were to determine the amount and type of fertilizer for sustainable cassava production in the area and to determine the nutrient status of soils of USSE OFFOT inland valley Uyo in Akwa Ibom State.

MATERIALS AND METHODS
Soil Location
Soil sample sites were located in USSE OFFOT Uyo area of Akwa Ibom State Nigeria. The approximate Co-ordinate of the area lies between latitude $4^{o}30^{1}$ $_{to}$ 5^{0} 30'N and Longitudes 7^{0} 31^{1} to 8^{0} 21^{1} E (Fig 1) at 61m elevation above sea level. The mean annual rainfall of the area is about 2,500mm; the mean annual temperature is about 26.5 ^{0}C- while the annual relative humidity is about 85%. The soil is derived from waste plain sands (Enwezor *et al* 1981). The soils are derived from coastal plain sand.

Field Study

Based on the preliminary/reconnaissance field study carried out in the inland valley, four slope positions were identified, thus upper slope (3%), middle slope (5%), hydromorphic fringe (6%) and Valley bottom (8%). Since the fertility status was compared the experimental design used in the study was Randomized Complete Block Design (RCBD), with the soil fertility being treatment and slope positions being replications

Sampling Scheme

Soil samples were collected at 0-15cm and 15-30cm depths for the top and sub soils respectively, from the four slop positions. In each slope position 24 (12 top and 12 sub) soil samples were collected making a total of 96 soil samples for the four slope positions. Thereafter the soil samples were preserved in polythene bags and transported to the laboratory. The samples were air dried and screened through a 2mm-sieve prior to laboratory analysis and samples were crushed further to pass through a 0.5mm sieve for total nitrogen and organic carbon.

Analytical Methods

Particle size distribution, soil pH, Exchangeable cations & acidity,

The particle size distribution was determined by the use of hydrometer method (Bouyoucos, 1951) using sodium hexametaphosphate as the dispersing agent. Soil pH was determined in water (1:2.5 soil/water suspension using a glass electrode pH meter (Ohiri and Ano 1988). Exchangeable cations in the soils was extracted with neutral molar ammonium acetate solution. Calcium and magnesium in the extracts were determined by EDTA titration while sodium and potassium were determined by photometry (Black, 1965). This was determined by leaching soil sample with neutral molar solution of KCI and the acidity estimated by titrating with 0.02M NaOH solution using phenolphthalein as indicator (Mclean, 1965)

Organic Carbon, Total N, Available P, CEC, etc.

This was determined by the potassium dichromate wet oxidation method of Walkley and Black (1934). Organic mater was obtained by multiplying the value of organic carbon by 1.724. This was determined by the modified Kjeldahl method (Black, 1965). Available P contents of the soils were determined by the use Bray No. 2 method (Bray and Kurtz, 1945). This was calculated as the sum of the exchangeable bases and the exchangeable acidity. Electrical conductivity was determined by the extract obtained from 1:2.5 soil-water ratios, suspension using a conductivity meter.

RESULTS AND DISCUSSION

Physical Properties, Sand, Silt and Clay fractions

The result of the physical properties of the soils studied is shown in Tables 1 and 2, while the range, mean, standard deviation values are shown in Table 3. Sand is the predominant fraction of the soils particles having a range of 85.8 to 91.8% and mean value of 88.55% and coefficient of variation of 3.31%, with soils of valley bottom having the highest sand values. The result obtained is typical of soils derived from coastal plain sand parent materials (Petters, 1995). The silt fraction of the soil particle ranged from 4.0 to 8.0% with mean value of 6.63% and coefficient of variation of 19.96%. There was no rigid pattern of silt distribution along the slope positions. This may be attributed to the unstable nature of the soils which are highly affected by erosion and leaching. The clay fraction distribution of the soil is low having a range of 3.2 to 8.2% with a mean value of 4.83% and coefficient of variation of 41.75%. The result showed that soils of the middle slope and hydromorphic fringe had the least clay fraction value of the soils particles. The low clay content of the soils may account for the loose nature and non-plastic consistency of the soil.

Table 1: Physical properties of USSE OFOT inland valley top soils (0-15cm).

Parameter	Slope Positions			
	Upper Slope	Middle Slope	Hydromorplic Fringe	Valley Bottom
Particle (size)				
Sand (%)	85.8	89.8	91.8	85.8
Silt (%)	6.0	6.0	4.0	8.0
Clay (%)	8.2	4.2	4.2	6.2
Tex Class	S	S	S	S

Table 2: Physical properties of USSE OFOT inland valley sub soils 15-30cm.

Parameter	Slope Positions			
	Upper Slope	**Middle Slope**	**Hydromorplic Fringe**	**Valley bottom**
Particle (size)				
Sand (%)	89.8	89.8	87.8	87.8
Silt (%)	7.0	6.0	8.0	8.0
Clay (%)	3.2	4.2	4.2	4.2
Tex Class	S	S	S	S

Table 3: Range, mean, standard deviation and coefficient of variability for the physical properties of USSE OFFOT inland valley soils.

Parameter	Range	Mean (x)	SD	CV (%)
Particle Size				
Sand (%)	85.8 – 9/.8	88.55	2.93	3.31
Silt (%)	4.0 – 8.0	6.63	1.32	19.96
Clay (%)	3.2 – 8.2	4.83	2.02	41.75

Primary Nutrient Properties

N, P and K are the primary nutrient most commonly demanded by roots and tuber crops most especially cassava. Results of N, P and K values of the soils studied are shown in tables 4 and 5, while values for the range, mean standard deviation are shown in table 6.

Total N, Available P and Exchangeable K

The total N contents in the soils were low to moderate ranging from 0.13 to 0.19% with mean value of 0.16% . The middle slope had the highest total N content in the soils. Variable response of applied nitrogen are thus expected in the soils. The available phosphorous values in the soils were very high and ranged from 79.65 to 93.32 mg kg-^{1}, with mean value of 84.53 mg kg^{-1}. The hydromorphic fringe had the least available P content in the solids. The soils were enormously endowed with available P content. Exchangeable potassium contents in the soils were low ranging from 0.12 to 0.17 cmol (+) kg^{-1}, with an average value of 0.14 cmol (+) kg^{-1}. The soils of the middle slope had the highest exchangeable K value. These soils had available K levels below the critical limit of 2.0 cmol (+) kg^{-1} recommended for soils of south eastern Nigeria (FFD 2002). This suggests that the soils will show substantial responses to applied potassium. There was no rigid distribution of the primary nutrient of the soils along slope positions

Table 4: Properties of Primary nutrient in USSE OFFOT inland valley top soils (0-15cm)

	Upper slope	Middle slope	Hydromorphic Fringe	Valley Bottom
Total N (%)	0.13	0.18	0.17	0.14
Avail P ($mgkg^{-1}$)	79.99	83.32	79.65	86.65
Exch.K ($cmol(+)kg^{-1}$)	0.13	0.17	0.15	0.14

Table 5: Properties of Primary nutrient in USSE OFFOT inland valley sub soils 15-30cm.

	Upper slope	Middle Slope	Hydromorphic Fringe	Valley Bottom
Total N (%)	0.15	0.19	0.14	0.17
Avail P ($mgkg^{-1}$)	93.32	89.99	73.33	89.99
Exch.K ($cmol(+)kg^{-1}$)	0.12	0.13	0.12	0.12

Table 6: Range mean standard deviation and coefficient of variability for primary nutrient properties of USSE OFFOT inland valley soils.

Parameter	Range	Mean	SD	CV (%)
Total N (%)	0.13 – 0.19	0.16	0.005	3.1
Avail P ($mgkg^{-1}$)	79.65 – 93.32	84.53	11.02	13.04
Exch.K ($cmol(+)kg^{-1}$	0.12 – 0.17	0.14	0.02	11.77

Selected Chemical properties

The results of some selected chemical properties of the soils studied are shown in Tables 7 and 8 while those of the range, mean, standard deviation and coefficient of variation are shown in Table 9

Electrical Conductivity

The values of electrical conductivity in the soils were low and ranged from 0.04 to 0.11 $d.sm^{-1}$ which is below the critical level value of 4 $d.sm^{-1}$, the mean value was 0.07 $d.sm^{-1}$. Soils of the upper slope had the least electrical conductivity value. The result of the electrical conductivity indicated that the soils were probably not saline and had no soluble salts (Onyekwere *et al,* 2001)

Soil Reaction

The soils were strongly to moderately acidic with a soil pH range of 4.3 to 5.1 with an average value of 4.7. Soils of the middle slope had the least pH value reduction of acidity with locally available liming materials and increasing the organic matter status of the soil provide good ameliorative options

Organic Carbon

Organic Carbon contents of the soils were low ranging from 0.72 to 1.88%. Soils of the middle slope had the highest organic carbon content. All the soils had values below 2% regarded as the critical organic carbon content in the soils. Maintenance of a satisfactory organic matter status is essential for the production of most of the nitrogen and half of the phosphorous taken up by unfertilized crops (Onyekwere *et al*, 2008)

Exchangeable Calcium, magnessium and sodium

The exchangeable calcium contents of the soils were low (1.60 to 4.80 cmol (+) kg^{-1}). The upper slope had the least values of exchangeable Ca in the soils. All the soils had values below the critical level of 5.0 cmol (+) kg^{-1} Amalu (1997). Exchangeable Magnesium contents in the soils studied were high ranging from 1.60 to 8.40 cmol (+) kg^{-1}. The soils had values above 0.5 cmol (+) kg^{-1} regarded as the critical value needed by soils (Onyekwere *et al*, 2003). The valley bottom had the least exchangeable mg in the soils. The values of exchangeable Sodium in the soils were low ranging from 0.02 to 0.05 cmol (+) kg^{-1}. The upper slope had the highest value of exchangeable sodium in the soils. The soils had values below 0.2 cmol (+) kg^{-1} regarded as the critical value needed by soils (Amalu 1997). This implies that these soils will considerable responses to sodium application.

Exchangeable Acidity

The exchangeable acidity content of the soils were high ranging from 1.20 to 3.48 cmol (+) kg^{-1} with mean value of 2.16 cmol (+) kg^{-1} and coefficient of variation of 50.57% with the upper slope recording the highest values. The high exchangeable acidity content in the soils is as a result of the low pH values of the soils.

Effective Cation Exchange Capacity (ECEC)

The ECEC of the studied soils ranged from 5.49 to 12.04 cmol (+) kg^{-1} with mean value of 9.48 cmol (+) kg^{-1} and coefficient of variation of 29.12%. This result indicated that the ECEC are low. The low ECEC and nutrient reserves in the soils have been attributed to the fact that soils of south eastern Nigeria are strongly weathered, have little or no content of weathered rocks in sand and silt fractions and have predominately kaolinete in their clay fractions (FPDD 1989)

Percentage Base Saturation

The percentage base saturation of the soils ranged from 60.91 to 89.44%.

Table 7: Some chemical properties of USSE OFFOT inland valley top soils (0-15cm)

	Upper Slope	Middle Slope	Hydromophic Fringe	Valley Bottom
EC (dsm^{-1})	0.04	0.11	0.09	0.06
PH (H20)	4.9	4.4	4.6	5.0
Org.C (%)	0.72	1.88	1.28	0.76
Exch.Bases(cmol(+)kg^{-1})				
Ca	1.60	4.00	4.00	4.40
Mg	8.40	3.6	3.00	2.40
Na	0.03	0.03	0.03	0.05
Exch -Acidity (cmol(+)kg^{-1}	1.20	3.48	1.44	1.20
ECEC	11.36	11.28	11.62	8.19
Base Saturation (%)	89.44	69.15	87.61	85.35

Table 8: Some chemical properties of USSE OFFOT inland valley sub soils (15-30cm) Parameter Slope Positions

	Upper Slope	Middle Slope	Hydromorphic Fringe	Valley bottom
EC (dsm^{-1})	0.04	0.06	0.09	0.04
pH (H20)	4.9	4.3	4.6	5.1
Org.C (%)	1.16	1.74	0.98	1.32
Exch. Bases (cmol(+)kg^{-1})				
Ca	2.00	4.00	4.80	2.40
Mg	1.60	4.40	2.00	1.60
Na	0.02	0.03	0.04	0.05
Exch.Acidity (cmol(+)kg^{-1})	2.40	3.48	2.76	1.32
ECEC (cmol(+)kg^{-1})	6.14	12.04	9.72	5.49
Base Saturation (%)	60.91	71.10	71.60	75.96

Table 9: Range mean standard deviation and coefficient of variability for primary nutrient properties of USSE OFFOT inland valley soils.

Parameter	Range	Mean (x)	SD	CV (%)
EC(dsm^{-1})	0.04 – 0.11	0.07	0.03	38.41
PH($H_2$0)	4.3 - 5.1	4.7	0.35	7.48
Org. C (%)	0.72 – 1.88	1.23	0.46	37.02
Exch. Bases (cmol(+)kg^{-1}				
Ca	1.60 – 4.80	3.30	1.12	33.91
Mg	1.60 - 8.40	3.75	2.78	74.18
Na	0.02 – 0.05	0.04	0.01	32.10
Exch.Acidity (cmol(+)kg^{-1}	1.20 – 3.48	2.16		
ECEC			1.09	50.57
Base Saturation(%)	5.49 – 12.04	9.48	2.76	29.12
	60.91 – 89.44	76.39	10.86	14.22

C/N and Exchangeable Cation Ratios

The results of the C/N, Ca/Mg and K/Mg ratios are shown in Tables 10 and 11

C/N Ratio

The C/N ratio contents of the soils ranged from 5.43 to 10.44 with soils of the middle slope having the highest values. All the values obtained were below 25 thus separating index for mineralization and immobilization of

Nitrogen as established by Paul and Clark (1989). Therefore applications of low rate of N to the soils will accerelerate mineralization (FFD 2002).

Ca/Mg Ratio

The Ca/Mg ratio content of the soils were low ranging from 0.19 to 2.4 with the valley bottom having the highest value for top soils while the hydromophic fringe had the highest value for the sub soils. This result indicates that though the P values of the soils are high, there is possibility of P inhibition as well as Ca deficiency since the ca/mg values were below 3.

K/Mg Ratio

The K/Mg ratio content of the soils ranged from 0.02 to 0.08 with the valley bottom soils having the highest value. The K/Mg values in the soils were lower than 2 indicating that Mg uptake by the cassava will not be a problem.

Table 10:C/N and Exchange Cation Ratios of USSE OFFOT inland valley top soils (0-15cm)

Parameter	Slope Positions			
	Upper Slope	Middle Slope	Hydromorphic Fringe	Valley Bottom
C/N	5.54	10.44	7.53	5.43
Ca/mg	0.19	1.11	0.67	1.83
K/mg	0.02	0.05	0.03	0.06

CONCLUSION AND RECOMMENDATION

The soils USSE OFFOT inland valley studied are sandy majority of the soils are strongly acidic. The soils have high P content which might be inhibited in the soil, low exchangeable bases and ECEC. To obtain higher yields of cassava in the soils the following remedial measures are recommended:

1. Liming the upper slope, middle slope and hydromorphic fringe soils at the rate of 0.5-1.0t/ha^{-1} to increase the pH soil to near neutral
2. Allowing the cassava plant residue in the farm after harvesting.
3. Application of 2t/ha of poultry manure. In addition to 300kg ha^{-1} of 15:15:15 NPK or 225kgha^{1} of 20:10:10 NPK fertilizer.
4. All the above measures will sustain good cassava yields in the study area.

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