Soil Fertility Asssessment of Cross River State Cocoa Producing Areas Nigeria.

Kekong, M. A. and Attoe, E. E.

Department of Agronomy, University of Cross River State Calabar.; *Corresponding Author Email: matikekong@gmail.com

Abstract

Cocoa is a major agricultural export crop of Nigeria that contributes substantially to the national economy in terms of employment and foreign exchange earning. An evaluation of the soil physical and chemical properties was carried out from June, 2024 to November, 2024, in fields located across major cocoa producing areas: Akamkpa, Boki, Etung, Ikom and Obubra Local Government Areas of Cross River State. Sixty (60) representative soil samples were collected from 30 selected cocoa farms and analyzed using standard laboratory procedures. Result indicated textural classes of loamy sand, sandy loam sandy clay loam, sandy clay and clay loam soils in the cocoa farms with a mean clay 30.02 percent, silt 13.49% and sand 56.43 the result of the chemical properties of the soils show means in the ranges of pH (5.31-5.64), Ec (0.021-0.023 ds/m), OM (2.81-3.36%)TN (0.07- 0.09%), Av.P (2.82-5.92 mg/kg), exch Mg (1.47-200 cmol/kg) exchange Na (0.05-0.06 cmol/kg) ECEC (6.73-8.94 cmol/kg) BS (77.25-82.70%). The base saturation, exchangeable calcium and magnesium and total nitrogen were adequate within recommended limit. Available phosphorus, potassium, organic matter electrical conductivity and effective cation exchange capacity were below the critical level. An appropriate and guarded nutrients restorative management practice using organic and inorganic sources is recommended for increased yields and sustainable cocoa production in these study areas.
Key words — soil samples, cocoa farm, soil textures, chemical properties, critical levels

Introduction: Cocoa is a major agricultural export crop of Nigeria and a major employer of labour, particularly in the crop's producing areas. The crop ranks first amongst agricultural export crops in its contribution to foreign exchange earning in Nigeria (Tijani, Farinde and Agboola 2001). Nigeria is the fourth largest world producer of cocoa after Corte' ivoire, Indonesia and Ghana and the third largest exporter (Verter and Becyarora 2014). Cross River State is the second largest producer of cocoa after Ondo in Nigeria (Iremiren, Oduwole, Obatolu, Aigbekaen, Sanusi, Shittu, Emeku, Ibiremo, Aikpokpodion, Agbeniyi, Ndubuaka, Adeogun and Olaiya 2012) while production data as at 2015 indicated that Boki, Etung, Ikom, Obubra and Akamkpa are the highest cocoa producers in Cross River State (Tiku, Galadima and Iyala 2016). The Nigeria cocoa economy has not been stable. The factors responsible for this fluctuating and declining yields are climate change and its impacts on soil properties and poor soil management practices among others. Aikpokpodion (2010) observed that most soils in Nigeria under cocoa plantations are marginal to moderately suitable in fertility status. Comparative studies between uncultivated forest and cocoa plantation soils indicated lower nutrient status in cocoa plantations (Ogunlade et al., 2006) Soil has been found to be the most heterogeneous substance on earth, whose properties vary significantly within a metre square. Cacao is exceptionally demanding in its soil requirement which shows steady decline in almost all nutrients with length of cultivation (Ogunlade, Adeoye Ipimoroti, Ibiremo and Iloyanomon, 2006).

Cacao is exceptionally demanding in its soil requirement which shows steady decline in almost all nutrients with length of cultivation (Ogunlade et al.,2006). Although few studies have been carried out in Cross River State cocoa soils, which is not sufficient, the inclement weather due to climate change impacts on soil dynamics in recent years calls for periodic assessment of soils of these areas if cocoa production has to be sustained. There is paucity of soil information in some potential areas of cocoa production in Cross River State such as Obubra and Akamkpa and the existing soil data bank in areas such as Ikom, Boki and Etung are fragmented. The lack of location specificity and multiple viewpoints makes soil information unsuitable for use for local and other investors in the cocoa industry and connectivity for

extension services. This study is designed to provide the background and context to Cross River State cocoa farmers and other agencies involved in cocoa production and development chain on soil potentials and management approaches for increased and sustainable yields. The productivity of plantation tree farming depends on the soil nutrients monitoring and replenishment with appropriate nutrients sources.

Materials and Methods : *Study Area and Sampling Technique* : The study was carried out at Akamkpa, Boki, Etung, Ikom and Obubra local government areas selected based on the report of Iremirenet al.,(2012). The coordinates of these areas were Akamkpa on latitude 5° 25'38.21'' N, and longitude 8° 31'6.78'' E with a land area of 4,300 Km^2, Boki latitude 5° 82 and 6° 40 N and longitude 8^0 50' and 9^0 00E with a land area of 2,771Km^2, Etung is latitude 5° 51'32''N and 6° 00N and longitude 8° 00 and 9° 00E with a land area of 815 Km^2, Ikom on latitude 5^0 57'40''N and 8^{0}42'39''E with a land area of 1,961 Km^2, Obubra on latitude 5^{0}44' to 6^{0}17'N and longitude 8^{0}11' to 8^{0}33'E with a land area of 903. 22 Km^2 all within the rainforest belt of Nigeria. The rainfall in this cocoa growing areas is bimodal in distribution and ranges from 1200 mm – 3000 mm in density NIMET (2008).The major economic activities of these areas is farming of food and cash crops including cocoa, which is the major cash crop.

Sampling Design and Soil Sampling : From each local government areas, three cocoa growing communities were randomly selected. In each cocoa growing community two farms were randomly selected making a total of 18 cocoa farms. The soil samples were taken from June to November 2024.

Soil Sampling : In each selected cocoa farm, two Quadrats of 50×50 m were marked. In each Quadrat, three representative core samples were collected randomly at depths of 0-25 cm and 25-50 cm using soil auger and bulked together for each depth to form a composite sample. A total of 60 (Sixty) representative soil samples were collected from 30 (Thirty) farms in Akamkpa, Boki, Etung, Ikom and Obubra. These samples were bagged and labeled in sampling bags then transported to Kaduna National Fertilizer Development Center Laboratory, Nigeria for standard laboratory analysis.

Soil Analysis : Prior to physicochemical analysis, the soils were air dried under room temperature, sieved through a 2 mm mesh.

Particle size distribution (PSD): was determined by the Bouyoucos (Hydrometer) method procedure by Udo, Ibia, Ogunwale, Ano and Esu (2009). This involves the suspension of soil samples with sodium hexametaphophate (calgon). The reading on the hydrometer was taken at 40 seconds. Second reading was taken three hours later. The particle size was then calculated using the following formula:

Sand = 100- (H1 + 0.2 (T1 – 68)-2.0)2
Clay = (H2 + 0.2 (T2 (T2-68) -2.0)2
Silt= 100 – (% sand + % clay)

where:

H1 = Hydrometer first reading at 40 seconds.
T1 = temperature first reading at 40 seconds.
H2 = Hydrometer second reading after 3 hours.
T2 = Temperature second reading after 3 hours.

1. Soil pH

This was determined in both water and 0.1 N KCL in a ratio of 1:1 soil: water and 1:2.5 soil: KCl respectively. After stirring the soil suspension for 30 minutes, the pH value was read using the glass electrode pH meter (McClean, 1982).

$$\%N = \frac{T \; X \; M \; X \; 14}{N} X100$$

where:

T = Titre value.
M = Molarity of HCl.
W = Weight of soil used.
N = Normality of H_2SO_4.

Available phosphorus : Available P was determined by Bray 1 method as outlined by Page et al., (1982). This involved mechanical shaking of the sample in an extracting solution then centrifuging the suspension at 2000 rotations per minutes for 10 minutes. Using ascorbic acid method, the percentage transmittance on the spectrophotometer at 660 nm wavelength was measured. The optical density (OD) of the standard solution was then plotted against the phosphorus ppm and the extractable P of the soil was then calculated.

Cation Exchange capacity (CEC) and Exchangeable acidity (EA) : These were determined by the Kjeldahl distillation and titration method as outlined by IITA, (1979). Using ammonium acetate solution, the soil samples were leached then the soil washed with methyl alcohol and allowed to dry. The soil was then distilled in Kjeldahl operation in to a 4% Boric acid solution. The distillate was then titrated with standard solution of 0.1 N HCl.

Exchangeable cations : This was determined by ammonium acetate extraction method as described by IITA, (1979). The soil samples were shaken for 2 hours then centrifuged at 2000 rpm for 5-10 minutes after decanting into a volumetric flask, ammonium acetate (30 ml) was added again and shaken for 30 minutes, centrifuged and the supernatant transferred into same volumetric flask. Atomic Absorption spectrophotometer (AAS) was used to read the cations

Organic Matter : This was determined by the walkley-Black method as outlined by Page, Miller, and Keeney (1982) which involves the oxidation with dichromate and tetraoxosulphate vi acid (H2 SO4). The excess was titrated against Ferrous Sulphate. The organic carbon was then calculated using the relationship:
( ) 1 2 – % . 0.3 N V V org C f W = □

where:

N = Normality of Ferous Sulphate solution.
V1 = Ml Ferrous Ammonium Sulphate for the black.
V2 = ml Ferrous Ammonium Sulphate for the sample.
W = mass of sample = farm.
f = correction factor = 1.33.
% organic matter in soil = % org.C × 1.729.

Nitrogen in soil : Total nitrogen in soil was determined by the macro Kjeldahl method as described by Udo et al., (2009). The soil samples were digested with Tetraoxosulphate (VI) acid (H2 S04) after addition of excess caustic soda. This was distilled into a 2% Boric acid (H3BO4) and then titrated with 0.01 HCl. And the nitrogen was obtained from the relationship.

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Results and Discussion: Physical Properties of the Soils

:Results of particle size distribution and textural classification of soils of Akamkpa, Boki, Etung, Ikom, and Obubra are presented in Table 1. The percentage sand composition of Akamkpa cocoa growing soils taken from 0 – 25 cm and 25 – 50 cm ranged from 57.0 74 with a mean of 66.0 %. The silt fraction ranged from 11.0 – 22.0 % with a mean of 17.0% while the clay content ranged from 12.0 -23.0 % with a mean of 16.0%. The textural classification of Akamkpa cocoa growing soils is predominantly sandy clay-loam with the exception of Osomba soils which texture at the 25 – 50 cm depth was loamy sand. The sand fraction of Boki soils ranged from 40.20 - 80.00 with a mean value of 60.52% at the 0 - 50cm. The silt content of the soils ranged from 10.00% - 23.00% with a mean value of 13.20% in soil depth of 0 - 50cm. The clay content ranged from 10.00%-36.00% with a mean value for the soils of 26.28%. The value for the 0-25cm depth of the soil particles were higher than at the 25cm-50cm. The textural classes for the Boki cocoa soils were loamy sand and sandy loam for the 0-25cm depth of Bunyia soils and sandy loam and sandy clay loam for the 25-50 cm depth soils of farms in Bunyia. The textural classes of Bashua indicated the soils as sandy loam and loamy sand for the 0-25cm depth and sandy clay loam for the 25-50cm depth. The textures for Olum soils were sandy clay and clay loam.

The soils of Etung cocoa farms of Agbokim, Bendegle and Ajassor have particle size distribution range of 39.40% -70% with a mean of 52.77%. The silt content ranged from 7.80% - 1980 for the 0-50cm soil depth with a mean of 14.02% while the clay content ranged from 22.20% - 42.40% for the soil depth of 0-50 cm with a mean value of 33.13%. Textural classes of Bendeghe was sandy loam at all the 0 - 50cm depth except for one farm whose soil was sandy loam at the 025 cm. The texture for all the farms for Agbokim at all depth was clay loam. Ajassor I cocoa farms had a texture of sandy clay while farms at Ajassor II were clay loam at the 0–25 cm and sandy-clay loam at the 25–50 cm depth. Ikom soils particle size distribution showed sand ranges from 42.00%-72.20% at the 0-50cm depth with a mean of 56.01% The percentage silt content of the soils ranged from 7.80-16.00% with a mean value of 13.26%. The clay content of Ikom soils range from 18.00% - 44.00% with a mean of 30.65% the texture classes of Ikom cocoa producing soil of Okuni were predominantly sandy loan. The last Motor soil showed the soil to be clay loam with same trend in Akparabong soils that showed clay loam of depths of 25 - 50 cm. The sand fraction of Obubra cocoa producing communities soils of Iyamitet, Onyen Okpon and Ochon ranged from 36.60 - 67.30 with a mean value of 50.00% at the 0 - 50cm. The silt content of the soils ranged from 14.20% - 44.00% with a mean value of 22.00% in soil depth of 0 - 50cm. The clay content ranged from 17.70%-36.00% with a mean value for the soils of 27.85. The textural classes for the Obubra cocoa soils were Clay loam for Iyamitet and Onyen Okpon while the textural class for Ochon soils was Sandy clay loam in both top soil and sub soil 25 cm – 50 cm.

The study area textural soil classes which indicated two for Akamkpa (Sandy clay loam and Loamy sand), five for Boki (Loamy sand, sandy loam, sandy clay loam, sandy clay and clay loam); Etung (sandy loam, sandy clay loam and clay loam) Ikom (four) sandy loam, sandy clay loam, sandy clay and clay loam and two textural classes for Obubra (clay loam and sandy clay loam) is an indication of spatial variability in soil universally. This heterogeneity of soil especially, in textures in these major cocoa producing areas of Cross River State, is in line with the studies of Amajor (1989) and Chude (1998) whose findings indicated that geology of central and southern Cross River State which include Akamkpa, Boki, Etung, Ikom and Obubra, comprise majorly of sand stones, silt stone, shale-Basalt and basement complex. The clay content of the soils has earlier been observed by Floyd (1962) and Ofem and Esu (2015) who reported that red clay is found within Ikom, Etung, some parts of Boki and Obubra which are described as ferruginous tropical soils. Soil texture is a very important property of soils as it regulates moisture, nutrients, microbial activities and pollutant movement in the rhizosphere. Njukeng and Baligar (2016) asserted that preferred soil textures for cocoa plants is 30% clay, 50% sand and 20% silt.The textural classes of these soils fall within the range recommended by Anim-Kwapong and Frimpong (2004) who stated that a model profile of cocoa growing soil should be deep well drained soil over sandy clay layer. This soil textural range also were recommended by Ritung, Agus, and Hidayat (2007) to be deep soils characterized by sandy clay, clay, and silt clay textures. The clay sand ratio in all the soil textural classes is indicative of the good drainage status which prevents excess soil moisture and consequently poor aeration for enhanced microbial activities and good root development of cacao as stated by Hardy (1960) ; Smyth (1966).

Soil pH, Electrical Conductivity (EC), Total N, Av. P, OM: *(Table 2)* pH of Akamkpa cocoa soils of Akin, Oban and Osomba ranged from 4.6 – 5.1 with a mean of 4.8. For Boki soils, the pH ranged from 5.2-6.10 for the 0-50 cm depth for the farms in Bunyia, Bashua and Olum with a mean of 5.64. Ikom soils of Akparabong, Last motor and Okuni pH ranged from 5.00 - 5.6 with a mean of 5.31; soil pH of Etung cocoa farms in Bendeghe, Agbokim and Ajassor ranged from 4.80-7.10 with a mean of 5.39 while the pH range for Obubra cocoa producing soils ranged from 4.8 – 5.7 with a mean value of 5.3 The electrical conductivity (EC) of Akamkpa soils ranged from 0.021 – 0.041 ds/m with a mean value of 0.031; Boki soils ranged from 0. 011ds/m - 0.031 ds/m with a mean 0.022ds/m. The EC of Etung cocoa farm soils ranged from 0.013 – 0.042 ds/m with a mean of 0.024 ds/m; Ikom EC ranged from 0.016 – 0.041 ds/m with a mean of 0.028 while the electrical conductivity of Obubra cocoa gowing soils ranged from 0.016 – 0.061 ds/m with a mean of 0.031.

The organic matter content of soils of the study area for Akamkpa ranged from 2.7 - 3.6% with a mean of 3.1 %. Boki cocoa farms have OM content that ranged from 2.21 – 5.27 % with a mean of 3.36%; Ikom 2.04-3.81 with a mean of 2.96%; Etung 1.87-4.59 with a mean of 2.96% while the values for Obubra ranged from 2.1 – 3.4 % with a mean of 2.83%. Total N for Akamkpa ranged from 0.09 – 0.17 % with a mean of 0.13%. Total N for Boki ranged from 0.06 -0.12 with a mean of 0.9%, Etung Total N ranged from 0.06 – 0.12% with a mean of 0.08, Ikom 0.05-0.10 with a mean of 0.07% while total N for Obubra soils ranged from 0.05-0.16 with a mean of 0.11%. Available P for Akamkpa ranged from 2.0 – 4.8 mg/kg with a mean of 3.37 mg/kg. Available P for Boki ranged from 3.40–9.17 mg/kg with a mean of 5.08 mg/kg; 3.00-11.51 mg/kg with a mean 5.90 mg/kg for Ikom; 1.00–5.36 mg/kg with mean of 2.82 mg/kg with of 2.82 mg/kg for Etung and a range of 6.52 – 9.0 mg/kg with a mean of 7.85 mg/kg.

Exchangeable Bases, Exchangeable Acidity (EA) ECEC and Base Saturation (BS) (Table 3)

The exchangeable cations content of soils in the study area showed that K in Akamkpa cocoa producing soils ranged from 0.01 – 0.12 cmol/kg with a mean of 0.11 cmol/kg. Concentration of K for Boki cocoa soils ranged from 0.09-0.17 with a mean of 0.12 cmol/kg. In Etung the K ranged from 0.09-0.14 with a mean of 0.12 cmol/kg; Ikom the range was 0.01-0.14 cmol/kg with a mean value of 10 cmol/kg while in Obubra the K ranged from 0.09 - 0.15 with a mean of 0.11 cmol/kg. Ca in Akamkpa cocoa producing areas ranged from 1.0 cmol/kg to 7.01 cmol/kg with a mean of 3.52 cmol/kg; in Boki it ranged from 4.00-6.00 cmol/kg with a mean of 5.18 cmol/kg. Ca in Etung ranged from 2.40 - 8.90 cmol/kg with a mean of 3.80 cmol/kg; Ikom cocoa producing area soils had Ca content of that ranged from 3.02-8.00 cmol/kg with a mean of 5.26 cmol/kg while Ca in Obubra soils ranged 4.00 - 6.4 cmol/kg with a mean of 5.2 cmol/kg. Mg content in Akamkpa soils ranged from 0.4 2.7 cmol/kg with a mean of 1.20 cmol/kg. In Boki soils it ranged from 1.40-2.7 cmol/kg with a mean of 2.00 cmol/kg; 1.40-3.00 cmol/kg with a mean of 1.98 in Ikom; 1.20-2.80 cmol/kg with a mean of 1.47 cmol/kg in Etung soils while the exchangeable Mg in Obubra cocoa producing soils ranged from 0.4 - 5.6 cmol/kg. Exch. Na

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in Akamkpa soils ranged from 0.05 – 0.09 cmol/kg with a mean of 0.08 cmol/kg; Boki was 0.03 -0.07 cmol/kg with a mean of 0.5 cmol/kg; 0.05-0.08 cmol/kg for soils of Ikom with a mean of 0.06 cmol/kg; Etung was 0.04-0.07 cmol/kg with a mean of 0.06 cmol/kg while the cocoa growing soils of Obubra had a Na content that ranged from 0.04 – 0.09cmol/kg with a mean of 0.07 cmol/kg. ECEC for Akamkpa soils ranged from 3.45 – 12.01 cmol/kg with a mean of 7.05 cmol/kg; Boki ranged from 7.78-10.62 cmol/kg with a mean of 8.97 cmol/kg; 5.96-12 .65cmol/kg with mean of 8.94 cmol/kg for Ikom; 5.09-13.05 with mean of 6.73cmol/kg in Etung soils while for Obubra soils the ECEC ranged from 6.60 – 22.41 cmol/kg with a mean of 9.59 cmol/kg. The base saturation of Akamkpa soils ranged from 50.0 88.0 % with a mean of 62.91%; for Boki it ranged from 78.02 - 83.71% with mean of 81.38 %; Etung the base saturation was 70.40–90.80 with mean of 77.25%; Ikom was 78.80 - 88.14% with mean of 82.70% and for Obubra cocoa soils the base saturation was 70.2 – 99.0% with a mean of 81.98%.

The pH range of the soils in the five main cocoa producing areas indicated that the soils were strongly, moderately to slightly acidic. The mean pH value of the soils is suitable for cacao growing and was within recommended pH of 5-8 by Ibiremo, Daniel, Iremiren and Fagbola (2011). This is also in line with the assertions of Aikpokpodion (2010), Wood and Lass (2001) that Cocoa in West Africa is widely grown on soils with either neutral or slightly acidic infertile soils. With exception of Total N (in Akamkpa, Boki and Obubra) Ca, Mg and Base Saturation, all other nutrients were below critical limits for cocoa productions. Nitrogen content in Akamkpa, Boki and Obubra soils were adequate and within the threshold for cocoa cultivation as the value was 0.09% and of N for cocoa (Egbe, Olatoye and Obatolu 1989; Aikpokpodion 2010). The higher N content of Akamkpa, Boki and Obubra cocoa soils could be attributed to the higher OM content of the farms over that of Ikom and Etung (Table 2).

The exchangeable Ca from the farms in Akamkpa, Boki, Ikom and Obubra were adequate for cocoa production as these were above 5.0 cmol/kg as recommended by Smyth, (1966) and Ibiremo et al., (2011). The deficiency of Ca in Nigerian cocoa soils in rare as concentration of Ca in these study area agree with the studies of Ipimoroti, Aikpokpodion and Akanbi (2009).The Mg content of all the cocoa farms investigated were higher than the critical level of 0.9 cmol/kg as stated by Ipimoroti et al.,(2009). The concentration of exchangeable Mg in cocoa farms soils of Akamkpa, Boki, Ikom and Obubra were above critical level and this was at variance from earlier studies by (Obatolu and Chude, (1987) and Ipimoroti et al., (2009).. The base saturation of all the investigated soils was higher than the critical level of 60% (Ibiremo et al.,2011) for good production of cocoa. These values were reported by Kekong and Undie (2020) for Ikom, Boki and Etung. The base saturation of Akamkpa, Boki, Ikom, Etung and Obubra (Table 3) indicate promising suitability of the soils for nutrients availability as aluminium toxicity is not envisaged as Brady and Weil (2014) stated that a non-acid cation saturation $\geq$ 20 cmol/kg soils will not likely be the problem of Al toxicity.

OM and EC levels of the cocoa soils of Akamkpa, Boki, Etung, Ikom and Obubra were below the critical limits, as established and recommended by Obigbesan (2009; Enwezor, Udo, Usoro,

Ayotade, Adekpeta, Chude, and Udegbe, (1989) for cocoa producing soils. The low EC of the soils indicates low concentration of soluble salts (Brady and Weil 2014) this Ec concentration indicated that the soils are likely to contain very little amount of soluble salts which is very conducive for cocoa production. The implication of low OM in these soils is low availability of adequate plant nutrients from native organic sources through mineralization. The low organic matter in these cocoa soils corroborates the assertions of Quaye, Doe, Attua, Yiran, Arthur, Dogbats, Konlan, Nkroma and Addo (2021) who noted that cocoa soils are low in organic carbon and require restoration. Low organic carbon in soils is low biological activities and diversity (Grover, Butterfly, Wang, Gleeson, Macdonald and Tang,2021) and consequently low mineralization. This calls for external intervention with inorganic fertilizers of N and P especially that are organic based. Hartmink, (2005) noted that larger amount of P is removed by beans, while (Ogunlade and Aikpokpodion (2006) reported that leaf litter in cocoa plantations was not sufficient to supply P required by cocoa trees for optical yields. Available P (Table 2) in the investigated cocoa farms in the five locations were below the critical level of 10 mg/kg. The low P in the soils of Southern Nigeria was reported by Ogunlade and Aikpokpodion (2006) particularly in the cocoa farm soils of South West. This low P in the cocoa farm soils corroborates the findings of Njukeng and Baligar(2016) who reported that P is the major limiting nutrient in almost all the soils under cocoa production. The low pH, OM and clay in the soils could be attributed to the low availability of P. This status of P agrees with theassertion of Ahenkorah (1981) who earlier noted that pH,OM and clay are associated with P availability in West African soils. Hartmink (2005) noted that larger amount of P is removed by beans, while Ogunlada (2006) reported that leaf litter in cocoa plantations was not sufficient to supply P required by cocoa trees for optimal yields. The K concentration in the cocoa soils of the study area is below the critical level of 0.25 cmol/kg Ibiremo et al.,(2011). The low P and K of soils in Etung (Ajassor and Agbokim) were similar to the findings of Ajiboye, Jaiyeoba, Olaiya and Hammed,(2015), while that of Ikom was reported by Esu, Uko, and Aki (2015). Although the pathways of P and K release and availability are not the same, application of these elements through inorganic fertilizers to the cocoa farms will increase yield of cocoa.

Conclusion: The soil textural classes of these major cocoa producing areas of Cross River State indicated suitability for cocoa production with adequate base saturation levels, Ca and Mg. These properties which are within the threshold for soil productivity is an indicator of quality cocoa beans production. But to match quality with quantity, the low levels of P, K, N, and OM requires external supplies with appropriate fertilizers to meet the high nutrients demand of cocoa trees. The thrust of the fertilizer application should be centered on phosphate availability management using organic and inorganic fertilizers in these cocoa growing areas. This will guarantee sustainable production of cocoa beans both in quantity and quality.

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TABLE 1:SOIL PHYSICAL PROPERTIES OF THE STUDY AREA

	Ikom						Etung						Boki					
S/N	Location	Depth cm	Sand %	Silt %	Clay %	Textural Class	Location	Depth cm	Sand	Silt	Clay	Textural Class	Location	Depth cm	Sand %	Silt %	Clay %	Textural Class
1	Aparabong I	0-25cm	54.00	9.60	36.40	SC	Bendeghe I	0-25cm	54.00	17.80	28.20	SCL	Bunyia I	0-25cm	74.20	12.80	13.00	SL
2		25-50cm	43.00	13.60	43.40	CL		25-50cm	50.00	19.80	30.20	SCL		25-50cm	72.00	12.00	16.00	SL
3	Aparabong II	0-25cm	44.00	15.60	40.40	CL	Bendeghe II	0-25cm	69.00	8.80	22.20	SL SCL	Bunyia II	0-25cm	62.20	13.80	24.00	SL SCL
4		25-50cm	46.00	15.60	38.40	CL		25-50cm	64.00	7.80	28.20			25-50cm	48.20	15.80	36.00	
5	Last Motor I	0-25cm	58.00	16.00	26.00	SCl	Agbokim I	0-25cm	54.00	13.80	32.20	CL	Bashua I	0-25cm	78.00	12.00	10.00	SL SCL
6		25-50cm	54.15	14.24	31.61			25-50cm	50.0	13.60	36.40	CL		25-50cm	59.20	13.20	27.60	
7	Last Motor II	0-25cm	58.20	10.80	31.00	CL	Agbokim II	0-25cm	46.00	13.60	40.40	CL	Bashua II	0-25cm	80.00	10.00	10.00	LS SCL
8		25-50cm	48.00	15.80	36.00	CL		25-50cm	46.00	13.00	40.40	CL		25-50cm	64.00	10.00	26.00	
9	Okuni I	0-25cm	57.00	16.00	27.00	CL	Ajassor I	0-25cm	45.40	14.20	40.40	SC	Olum I	0-25cm	58.20	5.80	36.00	SC CL
10		25-50cm	52.15	15.24	32.61	CL		25-50cm	38.40	19.20	42.40	SC		25-50cm	48.20	15.80	36.00	
11		0-25cm	65.00	10.00	25.00	CL		0-25cm	50.20	17.80	32.00			0-25cm	51.80	13.40	34.80	CL
12	Okuni II	25-50cm	57.20	16.80	36.00	CL	Ajassor II	25-50cm	52.77	14.02	33.13	LSC	Olum II	25-50cm	40.20	23.80	36.00	CL

	Akamkpa						**Obubra**					
S/N	Location	Depth cm	Sand %	Silt %	Clay %	Textural Class	Location	Depth cm	Sand %	Silt %	Clay %	Textural Class
1	Akin I	0-25cm	62.0	17.0	21.0	SCL	IyamitetI	0-25cm	49.3	33.0	17.7	CL
2		25-50cm	61.0	16.0	23.0	SCL		25-50cm	48.00	15.00	36.80	CL
3	Akin II	0-25cm	57.0	22.0	21.0	SCL	Iyamitet II	0-25cm	36.6	44.0	19.4	CL
4		25-50cm	58.0	20.0	22.0			25-50cm	48.00	15.80	36.00	CL
5	Oba I	0-25cm	74.0	12.0	14.0	SCL	Onyenokpon I	0-25cm	41.3	25.0	33.7	CL
6		25-50cm	72.0	11.0	17.0			25-50cm	52.15	15.24	32.61	CL
7	Oban II	0-25cm	65.0	17.0	16.0	SCL	Onyenokpon II	0-25cm	48.2	32.4	19.4	CL
8		25-50cm	70.0	16.0	14.0			25-50cm	57.20	16.80	36.0	CL
9	Osomba I	0-25cm	71	18	11.0	SCL	OchonI	0-25cm	67.3	15.0	17.7	SCL
10		25-50cm	68	14	12.0	LS		25-50cm	61.40	14.20	24.4	SCL
11		0-25cm	68.0	20.0	12.0	SCL		0-25cm	58.00	16.00	26.00	SCL
12	Osomba II	25-50cm	66.0	21.0	13.0	SCL	Ochon II	25-50cm	40.20	23.80	36.00	SCL

LS= Loamy Sand, SL=Sandy loam, SCL=Sandy Clay Loam, SC=Sandy Clay, CL=Clay Loam, LS= Loamy sand

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Ikom / Etung / Boki

S/N	Location	Depth cm	Ph	Ec Ds/M	Om %	Total N %	Av. P Mg/Kg	Location	Ph	Ec Ds/M	Om %	Total N %	Av. P Mg/Kg	Location	Ph	Ec Ds/M	Om %	Total N %	Av. P Mg/Kg
1	Aparabong I	0-25cm	5.10	0.022	3.37	0.08	7.01	Bendeghe I	7.10	0.021	2.89	0.07	1.67	Bunyia I	6.00	0.023	5.57	0.11	3.80
2		25-50cm	5.30	0.040	3.81	0.10	11.51		5.90	0.018	2.90	0.08	1.60		5.80	0.021	2.55	0.08	4.60
3	Aparabong II	0-25cm	5.10	0.041	2.72	0.06	3.50	Bendeghe II	5.80	0.013	4.59	0.12	4.50	Bunyia II	6.10	0.031	4.25	0.12	5.80
4		25-50cm	5.20	0.031	2.21	0.08	5.00		6.40	0.014	4.30	0.11	5.36		5.9	0.024	3.84	0.07	4.40
5	Last Motor I	0-25cm	5.40	0.026	3.13	0.08	3.40	Agbokim I	5.00	0.020	3.64	0.10	5.50	Bashua I	5.30	0.011	3.33	0.10	5.00
6		25-50cm	5.20	0.026	2.79	0.07	3.40		4.80	0.023	2.38	0.06	2.34		5.20	0.022	2.21	0.08	3.40
7	Last Motor II	0-25cm	5.70	0.016	3.23	0.08	4.84	Agbokim II	5.20	0.040	2.89	0.07	2.01	Bashua II	5.30	0.020	3.23	0.09	5.10
8		25-50cm	5.60	0.020	3.24	0.07	2.20		4.90	0.042	1.87	0.05	1.17		5.20	0.021	2.55	0.06	3.62
9	Okuni I	0-25cm	5.55	0.017	2.98	0.09	6.40	Ajassor I	4.90	0.030	2.89	0.07	1.50	Olum I	5.70	0.016	3.23	0.08	4.84
10		25-50cm	5.20	0.019	2.84	0.07	5.80		4.80	0.031	2.58	0.06	1.00		5.60	0.020	3.24	0.07	5.84
11	Okuni II	0-25cm	5.40	0.021	3.05	0.10	7.10	Ajassor II	4.90	0.032	2.61	0.07	5.00	Olum II	6.00	0.021	2.72	0.06	9.17
12		25-50cm	5.12	0.019	2.91	0.08	5.40		5.00	0.030	2.00	0.06	2.17		5.60	0.024	3.58	0.10	5.42
	Mean		5.31	0.022	2.81	0.07	5.90		5.39	0.026	2.96	0.08	2.82		5.64	0.021	3.36	0.08	5.08

Akamkpa / Obubra

S/N	Location	Depth cm	Ph	Ec Ds/M	Om %	Total N %	Av. P Mg/Kg	Location	Depth cm	Ph	Ec Ds/M	Om %	Total N %	Av. P Mg/Kg
1	Akin I	0-25cm	4.9	0.021	3.5	0.10	2.0	Iyamitet I	0-25cm	5.7	0.031	3.2	0.10	8.37
2		25-50cm	4.6	0.030	2.8	0.09	2.0		25-50cm	4.9	0.028	2.1	0.08	6.52
3	Akin II	0-25cm	5.1	0.026	3.4	0.11	4.1	Iyamitet II	0-25cm	5.6	0.019	2.9	0.11	9.01
4		25-50cm	4.8	0.026	3.0	0.09	3.8		25-50cm	5.2	0.016	3.1	0.05	7.80
5	Oba I	0-25cm	4.8	0.024	3.6	0.12	3.3	Onyenokpon I	0-25cm	5.2	0.061	2.8	0.16	7.12
6		25-50cm	4.6	0.022	2.9	0.10	3.0		25-50cm	4.8	0.055	2.6	0.12	6.81
7	Oban II	0-25cm	4.9	0.031	3.4	0.13	2.9	Onyenokpon II	0-25cm	5.5	0.025	3.4	0.15	9.40
8		25-50cm	4.5	0.030	2.9	0.09	3.1		25-50cm	5.1	0.019	2.7	0.10	7.21
9	Osomba I	0-25cm	5.0	0.041	3.2	0.15	4.8	Ochon I	0-25cm	5.6	0.022	2.9	0.14	8.10
10		25-50cm	4.6	0.040	2.9	0.3	3.6		25-50cm	5.4	0.020	2.5	0.09	6.9
11	Osomba II	0-25cm	4.8	0.039	2.9	0.17	4.1	Ochon II	0-25cm	5.7	0.042	2.8	0.08	9.10
12		25-50cm	4.6	0.031	2.7	0.15	3.7		25-50cm	5.4	0.031	3.0	0.09	8.50
	Mean													

TABLE 2: Chemical PROPERTIES OF THE COCOA SOILS

EC= Electrical Conductivity, OM= Organic matter, T. N= Total Nitrogen, Av. P= available Phosphorus

Ikom	Etung	Boki

Soil Fertility Asssessment of Cross River State Cocoa Producing Areas Nigeria.

Exhangeable Bases cmol/kg

S/N	Location	Depth cm	Ca	Mg	K	EA cmol/kg	ECEC cmol/kg	BASL SAT. %
1	Aparabong I	0-25cm	3.02	1.40	0.01	1.30	5.96	78.19
2		25-50cm	6.00	2.00	0.11	1.20	9.36	87.18
3	Aparabong II	0-25cm	4.00	1.40	0.13	1.60	7.30	78.08
4		25-50cm	4.40	1.50	0.14	1.30	7.42	82.48
5		0-25cm	5.20	1.80	0.10	1.54	8.70	82.30
6	Last Motor	25-50cm	5.21	1.60	0.12	1.50	8.49	82.33
			4.67	1.67	0.12	1.41	7.89	81.76
7	Last Motor II	0-25cm	6.00	2.70	0.12	1.73	10.62	83.71
8		25-50cm	4.00	1.60	0.09	1.62	7.73	78.66
9	Okuni I	0-25cm	7.01	2.50	0.11	1.64	11.01	87.73
10		25-50cm	5.50	1.53	0.09	1.66	9.10	78.90
11	Okuni II	0-25cm	6.40	2.80	0.12	1.71	12.01	78.10
12		25-50cm	6.10	1.92	0.08	1.61	9.91	82.24
	Mean		5.26	1.98	0.10	1.50	8.94	82.70

Exhangeable Bases cmol/kg

Location	Ca	Mg	Na	K	EA cmol/kg	ECEC cmol/kg	BASL SAT. %
Bendeghe I	3.20	1.40	0.05	0.12	1.03	5.80	82.24
	4.00	1.30	0.07	0.09	1.20	5.66	78.8
Bendeghe II	4.40	1.40	0.06	0.10	1.30	7.26	82.09
	8.90	2.80	0.05	0.10	1.20	13.05	90.80
	2.40	1.20	0.06	0.13	1.40	5.09	72.50
Agbokim I	2.80	1.30	0.06	0.09	1.50	5.74	73.87
Agbokim II	2.80	1.20	0.06	0.09	1.50	5.65	73.45
	4.00	1.30	0.07	0.11	1.60	7.07	77.37
Ajassor I	3.20	1.50	0.04	0.16	1.82	6.72	72.92
	2.70	1.40	0.06	0.10	1.79	6.05	70.41
Ajassor II	3.20	1.40	0.06	0.13	1.60	6.38	75.08
	4.00	1.50	0.05	0.14	1.66	7.35	77.41
Mean	3.80	1.17	0.06	0.11	1.47	6.73	77.25

Exhangeable Bases cmol/kg

Location	Ca	Mg	Na	K	EA cmol/kg	ECEC cmol/kg	BASL SAT. %
Bunyi I	0.12	5.40	1.4	0.05	1.40	8.37	82.27
	0.13	5.10	2.0	0.04	1.50	8.77	82.90
Bunyia II	0.11	5.30	2.4	0.06	1.60	9.47	83.10
	0.13	4.80	2.2	0.05	1.40	8.58	83.68
	0.16	5.20	1.90	0.07	1.50	8.83	83.11
Bashua I	0.17	5.60	2.00	0.06	1.54	9.37	83.56
Bashua II	0.13	5.40	2.10	0.05	1.52	9.20	83.48
	0.12	5.40	2.00	0.05	1.55	9.12	83.00
Olum I	0.12	6.00	2.70	0.07	1.73	10.62	83.70
	0.09	4.00	1.60	0.06	1.62	7.37	78.02
Olum II	0.11	5.60	2.20	0.06	1.60	9.58	83.30
	0.09	4.40	1.60	0.03	1.66	7.78	78.66
Mean	5.18	2.00	0.05	0.12	1.55	8.79	81.38

Akamkpa — Exhangeable Bases cmol/kg

S/N	Location	Depth cm	Ca	Mg	K	Na	EA cmol/kg	ECEC cmol/kg	BASL SAT. %
1	Akin I	0-25cm	5.8	1.2	0.11	0.09	1.47	8.24	88.0
2		25-50cm	1.8	0.4	0.07	0.06	1.58	4.67	51.0
3	Akin II	0-25cm	2.3	0.5	0.09	0.07	1.61	4.92	64.23
4		25-50cm	1.0	0.5	0.01	0.06	1.48	3.45	47.54
5	Oban I	0-25cm	2.2	0.8	0.01	0.08	1.59	5.18	61.0
6		25-50cm	2.2	0.8	0.11	0.05	1.61	5.87	50.0
7	Oban II	0-25cm	2.5	1.5	0.11	0.09	1.60	5.44	77.2
8		25-50cm	2.0	0.4	0.10	0.08	1.63	5.87	64.0
9	Osomba I	0-25cm	6.00	2.70	0.12	0.07	1.73	10.62	83.71
10		25-50cm	4.00	1.60	0.09	0.06	1.62	7.37	78.66
11	Osomba II	0-25cm	7.01	2.50	0.11	0.04	1.64	11.01	87.73
12		25-50cm	5.50	1.53	0.09	0.06	1.71	12.01	78.10
	Mean								

Obubra — Exhangeable Bases cmol/kg

Location	Ca	Mg	Na	K	EA cmol/kg	ECEC cmol/kg	BASL SAT. %
Bendeghe I	5.4	0.4	0.11	0.09	1.61	6.79	88.0
	5.0	2.2	0.12	0.10	1.58	10.66	70.0
Bendeghe II	5.4	0.4	0.11	0.08	1.49	6.79	88.0
	4.00	1.60	0.l5	0.05	1.80	7.60	76.32
	16.4	5.6	0.13	0.10	1.70	22.43	99.0
Agbokim I	6.40	2.40	0.10	0.04	1.60	10.54	84.82
Agbokim II	6.00	2.70	0.12	0.07	1.73	10.62	83.71
	4.80	1.60	0.09	0.06	1.62	7.37	78.02
Ajassor I	4.40	0.60	0.10	0.08	1.58	6.74	77.00
	4.00	1.60	0.15	0.05	1.60	7.60	76.32
Ajassor II	6.00	2.70	0.12	0.07	1.73	10.62	83.71
	4.00	1.60	0.09	0.06	1.62	7.37	78.90
Mean							

TABLE 3:EXCHANGEABLE CATIONS OF THE COCOA SOILS
EA= Exchangeable acidity, BS= Base Saturation, ECEC= Effective Cation Exchange Capacity.

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