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Assessment of Soil Fertility for Cocoa Production in Kwara State: Southern Guinea Savanna Zone of Nigeria

O. S. Ibiremo, R. R. Ipinmoroti, M. O. Ogunlade, M. A. Daniel and G. O. Iremiren

Cocoa Research Institute of Nigeria Ibadan, P.M.B 5244 Ibadan, Nigeria
E-mail: femiibiremo@ yahoo.com

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ABSTRACT Cocoa industry that had contributed substantially to the growth of Nigerian economy suffered decline since the mid-1970's due to farm abandonment, poor pricing as a result of poor quality produce and rural-urban drift in most cocoa producing communities. Hence, the Nigerian government established the National Cocoa Development Committee (NCDC) with clear terms of reference to revamp the ailing cocoa economy particularly through rehabilitation and replanting most especially in marginal areas such as the Southern Guinea Savanna zone of Nigeria. Part of the zone includes Kwara State and soils of the southern part of the state comprising eight local Government Areas (LGAs) were evaluated for the suitability for cocoa production. The study was conducted using stratified-random sampling technique to a depth of 90cm. Analytical results indicated that the soil pH of the eight LG areas were between 5.58 -7.16 while Oke-Ero LGA had the minimum sand fraction of 540.0g/kg and Offa LG had the highest sand fraction of 677.20g/kg. The silt fraction of the soil ranged from 81.85g/kg in Ekiti LGA to 201.40g/kg in Offa LGA. The total soil nitrogen was at the moderate range of 0.81g/kg in Asa LG to 1.44g/kg in Isin LG while the available P in all the eight LGAs were far below the critical level required for cocoa production. The available P ranged from 2.28mg/kg in Ekiti LGA. to 6.41mg/kg in Ifelodun LGA. The exchangeable potassium ranged from 0.28 cmol/kg in Irepodun LGA to 0.62cmol/kg in Oyun LGA. Similarly, the soil organic carbon ranged from 8.76g/kg soil in Irepodun LGA to 13.06g/kg in Oke-Ero LGA. It is therefore essential that phosphate fertilizer be applied in the management of soils in all the LGAs evaluated. Hence, each of the LGAs areas namely, Asa, Oyun, Isin, Oke-Ero, Irepodun, Ekiti, Offa and Ifelodun would require 145 – 350, 90 – 120, 114 – 160, 174 – 190, 25 – 60, 184 – 192, 135, and 130 – 200 P_2O_5kg/ha respectively. It is also recommended that there should be irrigation facilities during the dry season because of the high level of sand fraction coupled with low annual rainfall in the areas.

INTRODUCTION

The cocoa industry was the dominant foreign exchange earner for Nigeria from the sixties through the mid-seventies. During this period the national production rose to over 307,000 metric tonnes of cocoa beans. The discovery and exploration of petroleum resulted in a shift from agrarian economic base to almost total dependence on petroleum. Nevertheless, cocoa still remains a major export crop with revenue of at least 190 million US dollars derived annually from export of cocoa beans alone, besides revenue from cocoa by-product like butter, cake, liquor and powder (Akinwale 2006). There has been policy shift to accord cocoa production which hitherto, had been the mainstay of our economy, the right priority. It is against this backdrop that the Nigerian government established the National Cocoa Development Committee (NCDC) whose main term of reference, is to revamp the ailing cocoa economy particularly through rehabilitation and replanting of this crop especially in marginal areas such as the Southern Guinea Savanna zone of Nigeria. Part of the zone include Kwara State. Soils of the southern part of Kwara State comprising eight local Government Areas (LGAs) were evaluated for their suitability for cocoa production. On a global scale, cocoa is grown successfully in many different kinds of soils. Smyth (1966) observed that unsuitable soil conditions, particularly those of a physical nature which may not be amenable to improvement, may impose a limitation on production regardless of the quality of the planting material used or the level of husbandry employed. This implies that planting cocoa on unsuitable soils will among other things leads to low productivity and poor economic returns. Cocoa is a tap-rooted plant and requires deep well-drained soils, free from iron concretions, high in nutrient content and topsoil rich in organic matter (Opeke 2005). Soils in south-western Nigeria had been classified according to their suitability for cocoa into four categories namely: Good cocoa soils, fairly good cocoa soils, poor cocoa soils and very poor cocoa soils (Smyth and Montgomery 1962; Hardy 1958). The previous survey on cocoa soils of south-western Nigeria also indicated that 62% of cocoa in the area was planted on good and fairly good soils while 38 % of the soils were planted on poor and very poor soils categories. This is the reason why nutritional problem is not that critical

in this region unlike many other cocoa producing regions where their production depends on fertilizer inputs. Hence, the objective of this study was to evaluate the soils of eight local Government areas in the southern part of Kwara State for their fertility status with reference to their suitability for cocoa production.

MATERIALS AND METHODS

Kwara State, is one of the fourteen cocoa producing states in Nigeria, and is located between Latitudes 7°N and 12°N and Longitudes 3°E and 7°E (Fig. 1). It is geographically located at the southern border of river Niger and in the southern guinea savanna. The average annual rainfall in the state is 1200 mm with two peaks in July and September and a dry spell in August. February to April are the hottest months while June to September has the lowest maximum temperature which coincides with the peak of the dry and wet seasons respectively (Ogunwale et al. 1999). The soils are formed from basement complex rocks (metamorphic and igneous rocks) which is about 95% and sedimentary rock along the Niger River bank which is about 5 % of the total area. The metamorphic rocks include biotite gnesiss, banded gnesiss, quartzite augitegnesiss and granitic gnesiss. The intrusive rock includes pegmatite and vein quartz (Smyth and Montgomery 1962; Olaniyan 2003; Lawal 1997). The study areas (eight Local Governments Areas) are located in the southern guinea savanna vegetational zones which is characterized by the presence of fire tolerant woody shrubs and trees that are about 12 meters high with grass of about 1.5-2.5 metres in height while some part of the study area has some rainforest trees and bushes. The main human activities in the area include animal husbandry and subsistence farming. The crops commonly grown include cassava, yam, melon, groundnut, sorghum, millet, pepper, tomato, and tree crops such as cocoa, kola, oil palm, mango, guava, citrus among others. The existing cocoa farms and some uncultivated forest soils were located along middle slopes and lower slopes on the catena in places like Edidi and Isanlu-Isin in Isin LGA. Most cocoa farms or potential cocoa farms are located on gentle to steep slopes.

Field Soil Sampling

In each local government, soil samples were collected from both cocoa farms and uncultivated forests. In all, twenty-three (23) sites were located from uncultivated lands proposed for cocoa where soil samples were collected across the eight local government areas. Soil samples were taken at 0 – 30 and 30 – 60cm soil depth using soil augers. The observation spots were selected in such a way that biased points like anthills and rocky spots were avoided. The soil samples were air-dried and sieved using a 2 mm sieve and were analysed for physical and chemical properties according to IITA 1982. Particle size was determined by Bouyoucos hydrometer method, soil pH was measured in 1:1 soil-water ratio using an EDT BA350 digital pH meter while organic carbon was determining by the wet digestion dichromate acid-oxidation method. Total N was determined using Kjeldahl digestion method and available P by Bray P1 method. Exchangeable cations (Ca^{2+}, Mg^{2+}, K^{+} and Na^{+}) were extracted with 1 N ammonium acetate (NH_4OAc) buffered at pH 7.0 (Thomas 1982). Exchangeable K and Na in the extracts were read through the Jenway flame photometer (model PFP7) and Ca and Mg were read on Atomic Absorption Spectrophotometer (AAS) (Buck Scientific 200A). Exchangeable acidity was extracted with I N KCl and determined by titration with 0.05 N NaOH using phenolphthalein indicator (McClean 1965), effective cation exchange capacity (ECEC) was obtained by summation method while percent base saturation was calculated as follows:

$$\% \text{ Base saturation} = \frac{\text{Exchangeable bases}}{\text{ECEC}} \times \frac{100}{1}$$

The fertilizer recommendations were based on the chemical properties of the top soil (0-30cm), the zone that houses both lateral and creeping roots.

RESULTS

Across the three locations of Ajegunle, Ipodin and Esie respectively in Irepodun LGA, sand fraction ranged from 560g/kg to 715g/kg (Table 1). In particular, Ajegunle has the highest mean sand fraction compared with the two other locations in the LGA. The silt fraction of Esie was higher than the level of silt in Ipodin and Ajegunle by 4% and 36% respectively. Ajegunle has the highest clay accumulation (133g/kg soil) compared with that of Esie with the least clay content (117.5g/kg). The pH of Ajegunle soil at 0-30cm

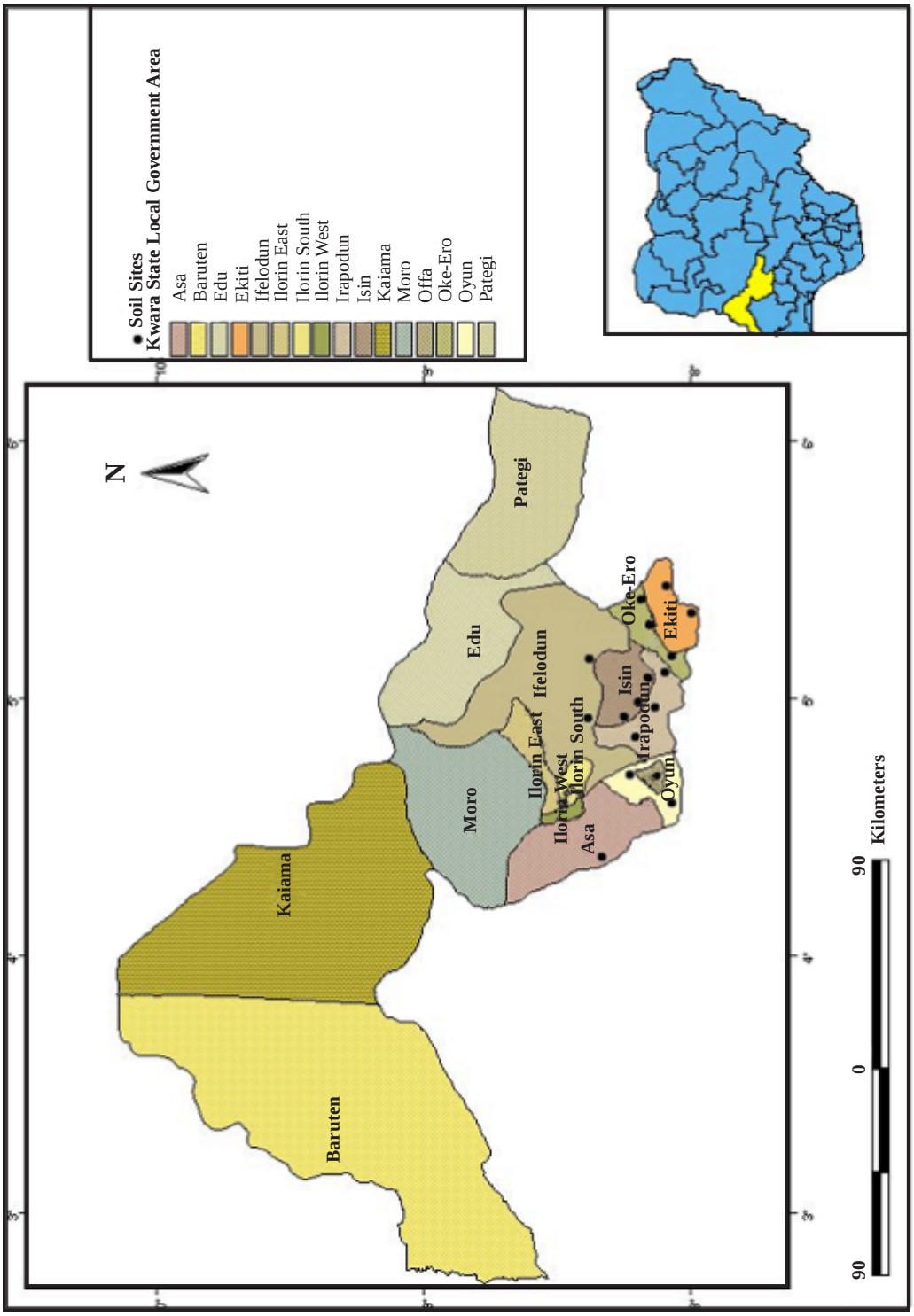

Fig. 1. Map showing the soil sampling sites in Kwara State, Nigeria

Table 1: Soil physical and chemical properties of some selected sites in Irepodun LGA of Kwara State of Nigeria

Site/soil depth	*Sand g/kg*	*S g/kg ilt*	*Clay g/kg*	*pH*	*OC g/kg*	*N g/kg*	*P mg/kg*	*K*	*Ca*	*Mg cmol/kg*	*Na*	*EA*	*ECEC*	*BS%*
Ajegunle														
0 -30cm	716	143	141	7.10	16.8	1.6	7.8	0.38	2.10	0.95	1.07	0.46	4.90	91.2
30 – 60cm	679	195	125	6.90	6.7	0.6	5.3	0.38	1.50	1.01	1.09	0.20	4.20	94.7
Ipodin														
0 -30cm	663	220	117	7.01	10.8	1.02	3.0	0.49	1.59	1.36	1.05	0.46	4.96	88.9
30 – 60cm	574	287	139	6.70	6.4	0.61	2.2	0.23	1.34	1.15	0.98	0.26	3.93	93.1
Esie														
0 -30cm	645	217	135	6.50	11.2	1.07	5.0	0.14	1.24	0.85	0.81	0.22	3.32	93.4
30 – 60cm	561	311	98	6.30	3.9	0.37	1.6	0.10	0.82	0.86	1.12	0.17	3.10	52.3

depth was7.1 while in Esie soil at 30-60 cm, the pH was 6.3, and pH decreases with depth. The soil organic carbon (SOC) and total nitrogen at 0-30cm soil depth were higher than 30-60cm. This indicates that SOC and total N were better accumulated at 0-30cm than 30-60cm. In Ajegunle, SOC at 0-30cm was 62 % higher than 30-60cm while in Ipodin, the SOC was 40% higher at 0-30cm compared with the 30-60cm. SOC at 0-30cm was 72% higher compared to the 30-60cm soil depth in Esie. The total N at the two depths in the three locations followed a similar trend as that obtained of SOC. The level of available P reduced with depth in all the three locations. Soil P was below the critical level of 10mg/Kg soil. The levels of N and P in the three locations within Irepodun LGA were low and thus, this soil will require amendment with fertilizers for optimum productivity. The exchangeable potassium was highest (0.38cm/kg) in Ajegunle compared with Ipodin and Esie locations. Similar trend was observed in the level of Mg. In the three locations, Effective Cation Exchange Capacity (ECEC) at 0-30 was 17% higher than at 30-60 cm.The soil matrix was well supplied with abundant base cations as the soil has 91% mean base saturation across the three locations.

In Isin LGA, the sand fraction ranged from 500g/kg to 684g/kg which is wider than that of Irepodun LGA while the silt ranged from 159 to 289g/kg. Olla has the least clay accumulation of 121g/kg while Eleyin has the highest clay content 192g/kg (Table 2). The mean clay content of 159g/kg was obtained across the three locations. The value is only moderate for cocoa. Evidences of clay accumulation (argillic horizon) are not visible in Olla and Oponda while there was a clay accumulation at Eleyin. The mean pH value across the three locations in the LG was 6.7 which was less than that of Irepodun LGA. The organic carbon in the three locations ranged from 5.2g/kg to 14.6g/kg. In the three locations, the OC at 0-30cm was 1.20% higher than at 30-60cm. This shows that more nutrients are located at 0-30cm. This explains why the total nitrogen was 140% higher at the 0-30cm than 30-60cm. The available P in all the three locations was very low with an average value of 4.5mg/kg. The highest available P (5.4g/kg) was obtained at Oponda while the least was observed in Eleyin (3.3g/kg). The average values for exchangeable K and Mg in Isin LGA were 0.35 and 2.2cmol/kg soil respectively. The values are adequate for cocoa production. The mean base saturation within the three locations was 92% which is adequate for crop production particularly cocoa.

In Oke-Ero LGA, sand fraction ranged from 503g/kg to 638g/kg in Ilofa and Idofin. The sand fraction averaged 574g/kg across the two depths (30-60cm and 0-30cm) (Table 3). The clay con-

Table 2: Soil physical and chemical properties of some selected sites in Isin LGA of Kwara State of Nigeria

Site/soil depth	*Sand g/kg*	*Silt g/kg*	*Clay g/kg*	*pH*	*OC g/kg*	*N g/kg*	*P mg/kg*	*K*	*Ca*	*Mg cmol/kg*	*Na*	*EA*	*ECEC*	*BS%*
Olla														
0 -30cm	677	160	163	6.6	14.6	1.30	4.4	0.40	1.70	0.60	0.90	048	3.98	88.8
30 – 60cm	684	195	121	6.9	5.2	0.70	4.5	0.30	1.50	0.80	080	0.32	4.19	91.4
Eleyin														
0 -30cm	640	185	175	6.3	12.6	1.19	5.5	0.31	1.93	0.61	099	0.52	4.31	89.9
30 – 60cm	501	289	210	6.9	7.1	0.67	1.6	0.28	1.44	0.94	1.04	0.26	3.95	93.4
Opanda														
0 -30cm	658	189	153	6.8	13.9	1.33	7.7	0.46	4.44	1.27	0.82	0.21	7.20	97.1
30 – 60cm	638	232	130	6.7	6.3	0.59	3.2	0.35	2.01	1.04	1.20	0.21	4.80	95.7

Table 3: Soil physical and chemical properties of some selected sites in Oke - Ero LGA of Kwara State of Nigeria

Site/soil depth	*Sand g/kg*	*Silt g/kg*	*Clay g/kg*	*pH*	*OC g/kg*	*N g/kg*	*P mg/kg*	*K*	*Ca*	*Mg cmol/kg*	*Na*	*EA*	*ECEC*	*BS%*
Erinmope														
0 -30cm	601	296	103	6.4	13.9	1.30	3.7	0.38	2.70	1.40	0.90	0.29	5.70	94.9
30 – 60cm	571	289	140	5.7	9.7	0.90	5.2	0.18	0.70	0.70	0.90	0.53	3.00	81.0
Idofin														
0 -30cm	638	249	113	6.8	15.4	1.50	2.5	0.48	3.13	1.33	0.93	0.48	6.26	93.5
30 – 60cm	581	277	142	6.5	10.5	1.00	4.0	0.44	1.06	0.43	0.57	0.28	2.79	90.9
Ilofa														
0 -30cm	504	160	336	6.5	21.2	2.02	3.7	0.43	3.25	1.07	0.89	0.33	5.96	93.5
30 – 60cm	553	365	82	6.3	9.4	089	4.1	0.29	1.54	1.28	1.06	1.96	6.11	68.1

tent ranged from 82g/kg to 336g/kg with an average value of 152g/kg soil. The clay in Oke Ero LGA was moderate for cocoa production. The mean pH value of 6.4 is suitable for cocoa production. SOC ranged from 9.4g/kg soil to 21.2g/kg soil in Oke Ero LGA with an average value of 13.35g/kg. It was observed that 60 % of the total SOC is concentrated at 0-30cm of the soil while the remaining is located in the 30-60cm. The distribution of the total N followed a similar trend with an average value of 1.27g/kg. The total N at 0-30cm soil depth of all the three locations was 72 % higher than that of 30-60cm. The available P in the three locations averaged 3.87mg/kg. The P is more concentrated at 30-60cm than at 0-30cm. The available P in the three locations was very low and cannot sustain cocoa production except with additional P input. The K and Ca in the soil were found to be adequate for cocoa production with average values of 0.36 and 2.06cmol/kg while the average base saturation across the sites considered was 86% which was 6% less than the mean value for the two LGAs earlier considered.

In Asa and Ekiti LGAs, the sand fraction ranged from 558g/kg to the 763g/kg while the silt ranged from 171g/kg/soil to 312g/kg. The clay content was particularly low in Awa- Atun and Osi-Ekiti in Ekiti LGA (Table 4). This has serious implications on the survival of cocoa especially in the establishment years. In Oniyere, the clay content was 57% and 34% higher than the clay in Awa-Atun and Osi-Ekiti respectively. The average pH in Awa-Atun and Osi-Ekiti was 6.9 while that of Oniyere was 5.2. The mean pH at 0-30 soil depth across the three locations was 6.7. The organic carbon of Awa- Atun at 0-30 cm was 141% higher than the organic carbon at 30-60cm while in Osi-Ekiti the organic carbon at 0-30cm was 352% higher than the organic carbon at 30-60cm. However, in Oniyere, the organic carbon was lower by 32% at 0-30cm compared to organic carbon at 30-60cm. In Awa-Atun and Osi-Ekiti, the total N at 0-30cm was 140% and 353% higher respectively compared to total N at 30-60cm soil depth. However, in Oniyere the total N at 0-30cm was lower by 32% compared to the total N at 30-60cm. The available P, of the three locations of Awa-Atun, Osi-Ekiti and Oniyere was very low. The available P at 0-30cm was generally higher compared to 30-60cm but they were below the critical level of 10mg/kg. This implies the need for P-fertilizers in the area. The exchangeable basic cations of K and Mg were moderate in the three locations. Potassium fertilizer may not be necessary within the first 2-3years of planting. The mean base saturation in the three sites within the LG was 90% indicating

Table 4: Soil physical and chemical properties of some selected sites in Ekiti and Asa LGA of Kwara State of Nigeria

Site/soil depth	*Sand g/kg*	*Silt g/kg*	*Clay g/kg*	*pH*	*OC g/kg*	*N g/kg*	*P mg/kg*	*K*	*Ca*	*Mg cmol/kg*	*Na*	*EA*	*ECEC*	*BS%*
Awa-Atum														
0 -30cm	604	311	85	6.8	13.5	1.13	2.5	0.51	3.61	1.55	0.66	1.25	6.62	96.6
30 – 60cm	763	171	66	7.1	5.6	0.47	1.9	0.23	1.17	0.93	0.89	0.21	5.62	87.3
Osi-Ekiti														
0 -30cm	648	271	81	6.8	16.3	1.36	2.8	0.49	0.91	1.49	0.97	0.58	5.23	87.9
30 – 60cm	613	291	96	6.9	3.6	0.30	2.0	0.31	0.89	1.11	1.07	0.20	4.77	87.9
Oniyere														
0 -30cm	685	209	106	6.6	6.7	0.56	4.3	0.51	2.40	1.15	0.89	0.36	7.70	96.7
30 – 60cm	558	312	130	3.8	9.9	0.83	2.4	0.32	6.50	0.89	0.89	0.28	5.70	87.6

Table 5: Soil physical and chemical properties of some selected sites in Oyun and Offa LGA of Kwara State of Nigeria

Site/soil depth	*Sand g/kg*	*Silt g/kg*	*Clay g/kg*	*pH*	*OC g/kg*	*N g/kg*	*P mg/kg*	*K*	*Ca*	*Mg*	*Na*	*EA*	*ECEC*	*BS%*
										cmol/kg				
Ilemona														
0 -30cm	704	139	157	7.3	9.7	0.92	6.4	0.51	5.11	1.36	0.99	0.99	8.37	95.4
30 – 60cm	628	253	119	7.4	11.4	1.08	3.5	0.62	3.30	1.69	1.08	1.08	7.00	94.9
Erin-Ile														
0 -30cm	658	227	115	6.9	11.8	0.88	5.2	0.83	5.09	1.50	1.01	1.01	8.73	96.6
30 – 60cm	635	273	92	7.3	8.5	0.81	4.1	0.53	3.17	1.24	1.02	1.02	6.13	96.7
Igbo-Odun														
0 -30cm	683	121	196	6.8	22.8	2.17	8.1	0.56	0.76	2.20	0.91	0.26	4.69	94.5
30 – 60cm	674	120	206	6.4	15.9	1.51	3.2	0.49	2.20	1.54	1.07	0.42	5.72	92.7

abundant supply of basic cations within the soil matrix.

In Asa and Offa LGAs, the sand fraction in the locations ranged from 628-704g/kg. The sand fraction was generally too high especially at Ilemona and Igbo-Odun in Asa and Offa LGAs respectively (Table 5). The sand at 0-30 cm was particularly higher in Ilemona and Erin-Ile compared to Igbo-Odun. The clay content averaged 147g/kg in the three locations across the various depths. The pH across the three locations was near neutral with an average value of 7.02. This can still permit the cultivation of cocoa because cocoa can thrive within the pH range of 5.5-7.5. The organic carbon across the various depths under consideration at the three locations was higher at 0-30cm particularly in Erin-Ile and Igbo-Odun. However, at Ilemona the organic carbon was lower at 0-30cm by 15% compared to the organic carbon at 30-60cm. The total N across the depths at the three locations followed a similar trend of organic carbon. However, the available P was generally very low in the three locations but at 0-30cm, the available P was higher compared to 30-60cm depth. The exchangeable bases of K, Ca and Mg were adequate for good cocoa production with average values of 0.59, 3.27 and 1.58 cmol/kg soil respectively. This is reflected in the ECEC that was generally higher across the three locations with an average value of 7.34cmol/kg soil. The soil matrix in the three locations was well saturated with bases that resulted in high base saturation of 95% across the three locations.

In Ifelodun LGA, the sand fraction ranged from 333g/kg to 801g/kg soil in the two locations of Ikosin and Owode-Ofaro while the silt ranged from 92 to 326g/kg (Table 6). In Owode-Ofaro the clay content at 30-60cm was 163 % higher than the clay at 0-30cm. The mean pH at Ikosin and Owode-Ofaro were 6.6 and 6.25 respectively. The organic carbon content at the 0-30cm was 19 % higher than the organic carbon at 30-60cm in the two locations. In the two locations, the average total N was 0.56g/kg soil across the various soil depths while the available P was 8.59mg/kg soil. The available P in the two locations was very low for good cocoa production. The exchangeable bases were 0.38, 1.83 and 1.39 cmol/kg respectively for K, Ca and Mg. The mean base saturation from the two locations considered was 92%.

DISCUSSION

Considering the physical and chemical properties of the soils in the cocoa growing LGAs in the state, there is need for careful management for optimum crop production. In all the locations in the LGAs, the soils were deep enough for proper development of cocoa roots. Hardy (1960) proposed a general rule of 1.5m as minimum soil

Table 6: Soil physical and chemical properties of some selected sites in Ifelodun LGA of Kwara State of Nigeria

Site/soil depth	*Sand g/kg*	*Silt g/kg*	*Clay g/kg*	*pH*	*OC g/kg*	*N g/kg*	*P mg/kg*	*K*	*Ca*	*Mg*	*Na*	*EA*	*ECEC*	*BS%*
										cmol/kg				
Ikosin														
0 -30cm	802	92	106	6.7	9.0	0.86	4.9	0.15	1.93	1.22	0.92	0.40	4.13	96.8
30 – 60cm	781	129	90	6.5	7.1	0.71	8.8	0.21	2.19	1.60	1.12	0.44	5.56	91.1
Owode Ofaro														
0 -30cm	753	118	129	7.2	5.3	0.36	8.8	0.63	1.44	1.38	0.94	0.38	4.60	95.9
30 – 60cm	334	326	340	5.3	4.9	0.30	11.4	0.52	1.78	1.38	0.54	0.40	4.91	86.9

depth for optimum cocoa growth. Nevertheless, where all other aspects of soil suitability parameters are met, soils with only 1m depth may be acceptable. The textural composition of the soils in the various locations studied indicated that the level of sand and clay fractions was adequate for cocoa production except Igbo-Odun in Offa LGA where the sand fraction was extremely too high for cocoa especially when irrigation is not being planned. The soil nitrogen content ranged from 0.56 – 2.17g/kg at the 0 – 30cm level and 0.30 – 1.51g/kg at the 30 – 60 cm level. The values decreased with soil depth but were highest at Oke – Ero LGA and followed by Ifelodun, Isin, Ekiti – Asa, Oyun – Offa and least at Ifelodun LGA. In Oyun – Offa and Ifelodun locations, the soil N levels were below the critical level of 0.9g/kg soil that has been previously established as ideal soils for cocoa cultivation in Nigeria (Egbe et al. 1989). The low N content of the soils was a reflection of the low organic carbon content. The organic carbon values ranged from 0.88 – 22.8g/kg at the 0 – 30cm depth and 0.81 – 15.9g/kg at the 30 – 60cm depth. The values similarly decreased with soil depth and were far below the critical value of 30.0g/kg reported to be ideal for suitable soils for cocoa cultivation in Nigeria (Omotoso1975). The soil organic carbon content was highest at Oke – Ero LGA and least at Oyun – Offa LGA. The low level of SOC indicated that the soils cannot supply N adequately and in a continuous manner to sustain cocoa requirement at optimal level without fertilizer application. The mean C/N across the LGAs was 10 which is above the minimum requirement of 9 for cocoa production (Egbe et al. 1989; Hardy 1958). The soil pH values ranged from 6.3 – 7.3 at the 0 – 30cm soil depth and 3.8 – 7.1 at the 30 – 60cm depth. This indicated that the soils were slightly acidic to slightly alkaline at the surface, while it is highly acidic to slightly alkaline down the soil depth. According to Wood (1989), cocoa can grow in a variable pH which may range from very acid (pH 5) to very alkaline (pH 8). The soils in these LGAs are suitable for cocoa production with reference to pH. The soil available P ranged from 2.5 – 8.8mg/kg with mean value of 5.07mg/kg at the 0 – 30cm depth, while it was 1.6 – 24mg/kg with a mean value of 4.69mg/kg at the 30 – 60cm depth. The values generally decreased from the upper to the lower depth and were grossly below the critical value of 10mg/kg for ideal soils for cocoa in Nigeria (Wood 1989). This indicates that P-fertilizer is needed on the cocoa farms across the various locations for good growth and sustainable optimum pod production.

The soil K contents range of 0.14 – 0.83cmol/kg with mean value of 0.39cmol/kg at the 0 – 30cm depth and 0.1 – 0.62cmol/kg with mean value of 0.34cmol/kg at the 30-60cm depth was observed to be higher than the critical value of 0.3cmolK/kg soil. It, therefore, indicated that K fertilizer would not be needed on the cocoa farms to achieve good cocoa growth on the soils in the first two years. This is consistent with the views expressed by Ipinmoroti et al. (2005) in which K was not in deficient level in some cocoa plots in Oyo state Nigeria. The soil Ca content was 0.91 – 4.44cmol/kg with mean value of 1.90cmol/kg at the 0 – 30cm depth, while it was 0.7 – 6.5ccmol/kg with mean value of 1.72cmol/kg at the 30 - 60cm depth. The values generally decreased with soil depth. The critical value of 5cmol/kg soil was calculated for Ca in an ideal cocoa soil (Smyth 1966), which shows that the soils Ca values were below critical. The soil Mg content was 0.60 – 2.20cmol/kg with mean value of 0.95cmol/kg at 0 – 30cm depth, while it was 0.43 – 1.69cmol/kg soil with mean of 0.79cmol/kg at 30 – 60cm depth. The soil Mg contents were far below the critical value of 0.9cmol/kg soil. The Ca:Mg ratio across the LGS ranged from 1 to 3 which falls within the adequacy range for cocoa production. The soil ECEC values ranged between 3.32 – 8.73cmol/kg with mean value of 3.99cmol/kg at the 0 – 30cm depth, while it was 2.79 – 6.11cmol/kg with mean value of 3.45 cmol/kg at the 30 – 60cm depth. There was no marked difference between the upper and lower soil depths in the soil ECEC values. The soil base saturation (BS) ranged from 87.9 – 97.1% with mean value of 93.76% at the 0 – 30cm soil level, while it was 68.1 – 96.7% with mean value of 89.73% at the 30 – 60cm depth. The BS was generally higher at the Oyun and Offa LGAs and least at Oke – Ero LGA sites. It can be inferred from this study that the soils at the various locations across the LGAs are low in the OC, P and Ca contents. The base saturation across the soils in the LGAs was 90 % which is above the minimum requirement of 60 % (Hardy 1958) for good cocoa production.

In the light of the above, the thrust of fertilizer application would be centered on phosphate fertilizer management in all the LG areas evaluated.

Hence, each of the LGAs namely, Asa, Oyun, Isin, .Oke-Ero, Irepodun, Ekiti, Offa and Ifelodun would require 145 – 350, 90 – 120, 114 – 160, 174 – 190, 25 – 60, 184 – 192, 135, and 130 – 200 P_2O_5kg/ha respectively.

CONCLUSION AND RECOMMENDATIONS

The soils of the selected sites from eight Local Government areas of Kwara State are moderately suitable for cocoa production and will require special management techniques to obtain optimal productivity of cocoa. Therefore, cocoa production is possible with moderate use of external inputs especially the combined use of organic and inorganic fertilizer application. It is also recommended that there should be irrigation facilities during the dry season because of the high level of sand fraction coupled with low annual rainfall in the study area.

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