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DESCRIPTION AND CHARACTERIZATION OF SOILS SUPPORTING *Vitellaria paradoxa* (SHEA TREE) IN DIFFERENT GEO-ECOLOGY IN NIGERIA

P.O. Oviasogie, E. Oko-Oboh and D.O. Oseghe
Chemistry Division, Nigerian Institute for Oil Palm Research (NIFOR)
P.M.B. 1030 Benin City, Edo State, Nigeria
Email: philipoviasogie5@yahoo.com

ABSTRACT

Characterization of soils supporting shea tree in different Geo-ecology was carried out. This was done using the International Plant Genetic Resources Institute (IPGRI) descriptors for environment and site characterization adapted from FAO. The result indicates that climate (Rainfall and Temperature) of the different geo-ecology has slight variation, but wide variations exist in the different locations in terms of topography, slope and general land form. However, there was a great similarity in vegetation in both locations but there was variation in the density and distribution of *Vitellaria paradoxa* in the different geo-ecology. Both locations have similar observable soil physical properties and parent materials, but the effective rooting depth is slightly deeper in Ofiki when compared with Konto-Karfi. However, there was no significant variation in chemical composition, as they are both Acresols and Rhousstalf.

INTRODUCTION

Soil description entails the recording of observable soil morphological properties which are often linked to laboratory measurement to aid soil classification (Soil survey Staff 1998; FAO *et al.,* 1998). However, the process of soil description and characterization involves the measurement or estimation of the quantitative and qualitative and qualitative attribute of land in a routine survey in any operational sense, including natural resources survey and remote sensing (FAO, 1976).

Shea tree, (*Vitellaria paradoxa)* Syn. *(Butyrospermum paradoxa)* of the family Sapotaceae, is an economic crop, which constitute important component in meeting both domestic and industrial requirement of a nation's agricultural economy. The trees produce shea nuts, which are used in the production of shea butter. In view of the great economic and nutritional potentials of the shea butter both locally and internationally, the demand for the commondity has been on a steady increase yearly. Unfortunately, the shea nut production and export fall far below demand. Thus calling for an intervention to increase the supply and also improve the quality. For instance the annual production level as at 2002 was estimated to be 371,000 metric tons while only 880 metric tons was exported from Nigeria. The estimated price per ton as at 2007 was N23,505 for wet season and N49,382 for dry season (Sulieman 2008). *Vitellaria paradoxa* are known to grow in the wild and its natural habitat stretches over Africa, South of the Savannah, from the

Eastern part of Senegal to the North of Uganda. This stretch covers an area of over 5,000 km long and 400 – 750 km wide. The West African subspecies is *V. paradoxa* var. *nilotica* is distributed in the eastern region and are indigenous to northern Uganda and South-Western Ethiopia. In Nigeria, the shea tree also occurs in the wild. It thrives well within the Guinea Savannah areas as well as the lower Sahel ecology, with a rainfall of 600 – 1,300 mm annually (World Agroforestry Center, 2008). Although the shea tree appears to be a rather obscure wild species, it is widely known, valued and exploited by the natives in all the areas where it occurs.

However, there is dearth of information on how much variation exists in soils supporting the growth and development of *Vitellaria paradoxa*. Therefore, it is difficult to state precisely the condition of soils supporting its growth and how this soil condition affects the distribution and yield of shea tree. In addition, this inadequate soil information has made it difficult to recommend precisely and appropriately, locations that are highly suitable for shea domestication. In order to resolve this and increase its production, adequate environmental information with respect to soil and climatic factors are required in different ecologies where shea trees are found.

The study was conducted to examine the relationship and variation in soils and climatic conditions of the different ecology supporting shea trees. Similarly, the study will help to generate relevant information in developing soil assessment indices for potential area of shea cultivation. In addition, a documented inventory of landform, physical and chemical condition of the soil supporting the growth of shea tree will be established.

MATERIALS AND METHODS

Study Area

The study was conducted in Koton Karfe Local Government Area of Kogi State on central Nigeria and Ofiki in North of Oyo State in South Western Nigeria. The two location both lies on latitude 08º 05.278′N and longitude 006º47.789′E and longitude N06º 08.647′ and latitude E 005º 44.162′ respectively.

Field Study

Field morphological characterizations which include relief, drainage, structural impediment and soil rooting depth were conducted in both locations, by systematically placing transect on already existing foot paths and other minor road perpendicular to the major road which serves as the base line. The transects were not equidistance from each other due to almost uniformity in vegetation and land form which formed the basis for variation in soils. In all, eight transects were established within the area and the approximate length of each transect was 650 m. Soils were examined along each transect where noticeable changes in vegetation and land form were apparent. The examination points were augered to a depth of 60cm in area where there are concretion and 90cm in areas where there are no concretion and at depth intervals of 0-15cm, 15cm – 30cm, 30cm – 45cm, 45cm – 60cm and 75cm – 90cm. Further depth could not be reached due to rocks and hard pans. Furthermore, texture, colour and other morphological properties were examined. All the examined and sample points were geo-referenced.

Soil excavation pits and road bands found sporadically in the area demarcated were used as an alternative to profile pits. These represented the area where vegetation and soil differences were noticed and were described according to the guidelines for soil profile description (FAO, 1990). Soil samples were collected from bottom of the chance profile to the top and put in polyethylene bags for laboratory analysis. Soil characterization was done in line with the International Plant Genetic Resources Institution (IPGRI) descriptors for environment and site characterization adapted from FAO (1990).

Laboratory Study

The soil samples collected were air dried at room temperature and sieved through a 2 mm sieve. The resulting soil samples were analyzed for their physical and chemical properties as follows: Particle size was determined by hydrometer method (Gee and Bander, 1986). Available Phosphorous (P) was determined by Bray P-I method (Anderson and Ingram, 1993). Total Nitrogen (N) was determined by macro-kjedhal method (Brookes *et al.*, 1985), Soil pH was determined in a 1:2 soil to water suspension using a pH meter (Maclean, 1982). Exchangeable bases were extracted using NH_4OAC buffered at pH 7.0 (Thomas, 1982). While Potassium (K) and Sodium (Na) were read from a flame photometer, Exchangeable Calcium (Ca) and Magnesium (Mg) were determined using atomic absorption spectrophotometer. Total Exchangeable acidity (H^+ + Al^{3+}) was by titration method (Anderson and Ingram, 1993) while effective cations exchange capacity was determined by summation of exchangeable cations and exchangeable acidity (Tan, 1996).

RESULTS AND DISCUSSION

The climatic data, phiscal and morphological properties of soils in the two locations are presented in Table 1 and the chemical properties in Table 2 and 3 repsectively.

The result showed that the mean annual rain fall for Konto kafi is between 700 mm – 133 mm, with mean annual temperature of 32^{o}C and 350 mm – 1100 mm, mean annual rainfall with mean annual temperature of about 30^{o}C for Ofiki (Nigerian Meteorological Agency). The topography in Konto kafi varied from gently undulating 3 – 5.9% to hilly 16 – 30% in Ofiki, the topography varied from almost flat 0.6 – 2.9% to gently undulating 3 – 5.9%. The land surface in Konto kafi, varied from upland to hill and undulating with rough terrain and rock outcrop but in Ofiki, it is a plateau which gradually descends into a valley in some parts of the area. The estimated slope degree varied from 0.6^o to > 3^o across the studied area with a straight and concave slope in both vertical and horizontal direction. Similarly, the slope degree in Konto kefi varied between 3^o to > 20^o with irregular shape in both vertical and horizontal direction.

The overall vegetation of the site in Konto karfi consists of mainly Savanna (Grasses with a discontinuous layer of shrubs) and riparian forest found along the stream. *Vitellaria paradoxa.* constitute the highest number of trees and shrubs in the area, with an estimated distant of 20 in between trees across the site. In Ofiki, the vegetation was similar with Konto kafi vegetation but the estimated distance between the dominant tree species *(Vitellaria paradoxa)* varied from 5–10m across the studied area. Both sites is characterized by small holder arable farmers with a common practice of shifting cultivation whereby the vegetation is slashed and burn.

The soils in both locations have similar observable properties in terms of parent material and a slight variation in effective soil depth. They are derived from the basement complex rocks, especially from gnesis, which is even grained and structurally coarse. The soil is possibly developed in-situ. The rock is fairly resistant to weathering, as evidenced from the presence of weatherable minerals found in the profile, despite the warm humid conditions. The effective soil depth varied from 40cm – 60cm in Konto kafi and between 50cm – 5cm in Ofiki. The soil is shallow, well drained and characterized with plinthite at a depth below 60cm in both locations. Few angular hard concretions are distributed uniformly throughout the profiles. The potential moisture retention of the soils and its susceptibility to water erosion in moderate.

The colour of the soil matrix material in the root zone recorded moist, varied between 10R 4/4 dark yellowish brown at the surface horizon and 10YR 8/6 yellow at the subsurface horizon in Konto karfi and Ofiki it varied from dusky reddish brown 2.5YR 2.5/2 at the surface horizon to red 2.5YR 5/6 at the subsurface horizon (Mussel colour, 1975).

The textural classes for the two locations were loamy sand to sand for Konto kafi and sandy loam to loamy sand for Ofiki (Table 1). Large rock and mineral fragments > 2mm were between 0-2% at 0-60cm depth and 15-409% at > 60cm depth in Konto kafi (Table 1). Chemical characteristics of the soil in the different location were also examined and it varied as follows: The soil of the two locations where moderately acidic with pH measured in water ranged from 4.5 to 5.8 for Konto kafi and 3.8 to 5.5 for Ofiki respectively. For Konto kafi, the value was irregularly distributed within the profile, while in Ofiki the highest value was recorded on the surface horizon (Table 2 and 3). The value of organic carbon for Konto kafi ranged from 0.33 g/kg – 1.57 g/kg, with the highest value recorded on the surface horizon and decreased regularly down the profile, while in Ofiki, the values range from 0.032 g/kg to 2.14 g/kg respectively. The value is irregularly distributed within the profile. The value of phosphorous (P) ranged from 4.16 ppm to 8.30 ppm for Konto kafi and 3.78 ppm to 34.33 ppm for Ofiki. The value decrease with increase depth in Konto kafi but in Ofiki, the values were irregularly distributed within the profile.

The effective cation exchange capacity (ECEC) ranged from 4.69 cmol/kg to 11.47 cmol/kg for Konto kafi. The highest value was recorded in 0-10cm depth. In Ofiki, the value ranged from 3.15 cmol/kg to 47.8 cmol/kg it increased irregularly with increase depth.

The soils is Konto kafi is classified as an Acrisol due to acid and low base status of the soil and the presence of ferruginous coocretion in the profile especially > 50cm depth (FAO UNESCO 1988) and Ultisols in the (USDA Soil Taxonomy 2006). In Ofiki, the soil is classified as Ustalf due to the presence of argillic B horizon with reddish colour throughout the soil profile and Rhodustalf as it has a sandy loam texture, low CEC and Ustic soil moisture regime (USDA Soil Taxonomy 2006). Luvisol in the (FAO UNESCO 1988)

The climatic data from both locations however, corresponds with the biophysical limit (rainfall, temperature and number of dry months) for shea tree growing ecology in other parts of the world (World Agro Forestry Center Reports). The soils in Konto kafi, is characterized by stones and plinthite at dept < 60cm with high percentage of large rocks and mineral fragment > 2 mm at depth > 60 cm when compared with Ofiki. This could be responsible for the low density of shea tree in Konto kafi. This is in line with the report of (World Agro forestry Center) which states that shea tree responds to strong and lateralithic soils with low yield and low density.

CONCLUSION

The results indicate that climate (rainfall and temperature) in the different geo-ecology has slight variation. However, they are in conformity with the climatic requirements for shea growing ecology. Also there is a wide variation in the different locations in terms of topography, slope and general landform. In terms of vegetation, both location exhibit great similarities, the only variation is the density and distribution of Vitellaria paradoxa (Shea tree). The density is higher in Ofiki when compare with Konto-karfi. The soils have similar observable physical properties in terms of parent material, but the effective rooting depth is slightly deeper in Ofiki when compared with Konto-karfi. However, there was no significant variationin soil chemical properties in the two locations.

Table 1: Physicochemical Properties of the Soils (Ofiki)

S/N	Soil Sample Description		pH (H_2O)	EC (µS/cm)	C (%)	N (%)	OM (%)	P (ppm)	----------------meq/100g---------------- Ca	Mg	Na	K	H+	AL3+	ECEC (meq/100g)	Clay (%)	Silt (%)	Sand (%)	CEC (meq/100g)
1.	FK_1	0-15 cm	4.7	82.5	0.910	0.012	1.57	4.180	2.49	0.43	0.613	0.444	8.5	0	3.15	14.3	10.1	75.6	2.970
2.	FK_1	15-30 cm	5.4	106.5	0.160	0.013	0.277	1.497	3.44	0.56	0.628	0.281	13.1	0	18.01	14.3	10.1	75.6	4.909
3.	FK_1	30-45 cm	5.4	60.1	0.461	0.028	0.719	0.655	2.72	1.92	0.666	0.261	9.6	1.2	16.37	19.3	9.1	71.6	5.567
4.	FK_1	45-60 cm	5.3	53.6	0.352	0.018	0.609	1.684	3.28	0.96	0.643	0.348	6.5	0	11.73	22.3	9.1	68.6	5.231
5.	FK_1	60-75 cm	5.1	47.8	0.192	0.019	0.332	1.543	2.96	2.32	0.613	0.302	12.7	0	18.90	23.3	9.1	67.6	6.213
6.	FK_1	75-90 cm	4.3	35.7	0.196	0.005	0.166	2.993	3.20	1.44	0.711	0.307	15.9	0	21.56	24.3	9.1	66.6	5.658
7.	FK_1	90-105 cm	4.4	31.4	0.032	0.002	0.055	0.094	4.16	2.64	0.628	0.583	9.5	1.1	18.63	24.8	9.1	66.1	8.011
8.	FK_1	105-120 cm	4.7	34.6	0.480	0.029	0.830	1.403	2.96	2.72	0.643	0.368	16.2	0	22.89	32.3	9.1	68.6	6.691
9.	FK_2	0-15 cm	4.9	66.3	2.144	0.197	3.707	1.450	2.72	1.94	0.823	0.440	19.9	0	48.71	2.3	4.1	93.6	5.923
10.	FK_2	15-30 cm	4.3	44.0	1.536	0.166	2.656	1.169	2.80	1.20	0.643	0.031	46.1	02	46.97	2.3	10.1	87.6	4.674
11.	FK_2	30-45 cm	4.3	32.4	0.096	0.005	0.166	13.432	3.76	1.76	0.658	0.169	16.7	0.4	22.97	3.3	10.1	8.6	5.67
12.	FK_2	45-60 cm	3.7	41.5	0.320	0.013	0.553	3.929	2.24	0.32	0.658	0.026	13.2	0	17.96	4.3	11.1	84.6	5.035
13.	FK_2	60-75 cm	3.4	36.3	0.384	0.019	0.664	3.414	1.60	0.96	0.681	0.297	4.5	0	8.68	4.9	9.1	86.6	4.178
14.	FK_2	75-90 cm	3.5	28.8	0.352	0.018	0.609	14.592	3.36	1.28	0.643	0.373	6.8	0	10.70	7.5	10.1	82.4	3.896

Table 2: Physicochemical Properties of the Soils (Kontokarfi

S/N	Soil Sample Description		pH (H_2O)	C (%)	N (%)	OM (%)	P (ppm)	----------------meq/100g---------------- Ca	Mg	Na	K	H+	AL3+	ECEC (meq/100g)	B.S (%)	Clay (%)	Silt (%)	Sand (%)
15.	SG_1	0-15 cm	5.10	1.41	0.09	2.42	5.40	3.92	2.24	0.22	0.18	0.60	-	7.16	91.62	6.2	8.2	85.6
16.	SG_2	15-30 cm	4.88	1.12	0.08	1.92	5.88	3.52	1.44	0.29	0.21	0.40	0.50	6.36	85.85	7.7	7.7	84.6
17.	SG_3	30-45 cm	4.51	1.03	0.08	1.77	4.61	2.88	1.44	0.21	0.14	0.20	0.80	5.67	82.36	10.2	2.2	87.6
18.	SG_4	0-15 cm	5.70	1.06	0.09	1.82	8.30	4.32	2.08	0.18	0.11	0.60	-	7.29	91.77	6.2	3.2	90.6
19.	SG_5	15-30 cm	5.88	0.89	0.06	1.53	7.15	4.16	0.96	0.21	0.11	0.50	-	5.94	91.58	6.7	2.7	90.6
20.	SG_6	30-45 cm	5.06	0.68	0.05	1.16	5.15	2.96	0.96	0.26	0.11	0.40	-	4.69	91.47	10.7	3.7	85.6
21.	SP_1	0-10 cm	5.45	1.57	0.11	2.70	6.61	7.24	3.16	0.22	0.15	0.70	-	11.47	93.90	7.2	1.2	91.6
22.	SP_2	10-66 cm	4.93	1.17	0.09	2.01	5.10	5.60	2.32	0.23	0.13	0.50	0.20	8.98	92.20	12.7	2.7	84.6
23.	SP_3	66-127 cm	5.49	1.09	0.09	1.87	5.00	4.72	2.04	0.26	0.07	0.40	0.60	8.09	87.64	21.7	2.7	75.6
24.	SP_4	127-162 cm	4.87	0.53	0.04	0.91	5.17	5.12	1.96	0.23	0.04	0.20	1.00	8.55	85.96	16.7	2.7	80.6
25.	SP_5	162-200 cm	4.72	0.33	0.04	0.56	4.50	4.16	2.32	0.26	0.05	0.10	1.30	8.19	82.91	19.7	1.7	78.6

Table 3: Data sheet of soil supporting *Vitellaria paradoxa,* in different Geo ecology

Location	**Konto kafi**	**Ofiki**
Latitude	08^{o} 05.278′N	E 005^{o} 44.162′
Longitude	006^{o} 47.789′E	N 06^{o} 08.647′
General landform	Varied from gently undulating to hill	Low hill with undulating topography
Slop gradient	3-5.9% to 16-30%	>
Surface Characteristics		
Rock outcrop	Present	Present
Stoniness	Evenly distributed within the profile	Evenly distributed within the profile
Cracking	Nil	Nil
Slaking/crusting	Nil	Nil
Solt/alkaline	Nil	Nil
Slope Processes		
Soil erosion	Moderate	No
Slope stability	-	Stable
Parent Material		
		Solid rock (granite)
Texture	Loamy sand to sand with large rock and mineral fragments	Sandy loam to loamy sand with coarse grain
Weathering degree	Moderate	High
Resistance	Fairly	Fairly
Effective soil depth	60cm	70cm
Water table (dept)	> 90 cm	> 90 cm (no water table observed)
Drainage	Well drained	Well drained
Permeability	High	High (slowly permeable layer at 100 cm)
Flooding frequency	Nil	Nil
Moisture condition in profile	0 – 99 cm dry	0 – 90 cm dry
Land use	Low level arable farming no irrigation, no mechanical, shifting-fallow grass	Low level arable farming no irrigation, no mechanical, shifting-fallow grass
Vegetation type	Savanna (Grasses with a discontinuous layer of shrubs) and riparian forest found along the stream.	Deciduous woodland
Climate		
Rainfall (mm)	Between 700 mm – 133 mm.	Between 350 – 110 mm
Temperature	32^{o}C	28^{o}C
Dry months duration	> 4 months	4 – 5 months

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