ASSESSMENT AND EVALUATION OF SOILS SUPPORTING SHEA TREE (*Vitellaria paradoxa* C.F. GAERTN) CULTIVATION IN BIDA, NIGER STATE, NIGERIA

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ABSTRACT
This study was conducted to evaluate the physical and chemical properties of soils for Shea tree cultivation in Bida Local Government Area of Niger State. Three profile pits were dug and soil samples were collected from each horizon. The textural classes identified were sandy loam at the surface to sandy clay at the sub-soil in all the profiles. The result revealed that all the soils belong to one soil order Alfisol, in USDA soil taxonomy or luvisols in the FAO/UNESCO system of classification. The soils were slightly acidic with pH values which range from 5.47 – 6.13. However, the fertility status of the soil with respect to Organic carbon, Total Nitrogen, Available Phosphorus and Exchangeable bases were low and varied from one profile to another. This can be corrected by application of mineral fertilizer nutrient Nitrogen, Phosphorus and Potassium fertilizers and the use of Organic manure such as cow dung and poultry dropping is recommended to improve the productivity of these soils for Shea tree cultivation in the area under study.

Keywords: *Assessment, evaluation, cultivation, Bida, shea tree.*

INTRODUCTION
Shea tree, (*Vitellaria paradoxa)* of the family Sapotaceae is one of several non-timber trees. The tree is not domesticated but grows naturally in the wid. It natural habitat stretches over African south of the savannah, from the eastern part of Senegal to the North Uganda where it is protected and managed (Hall *et al.*, 1996; Maranz *et al.*, 2004). This stretch covers an area of over 5000 km long and 400-750 km wide in Nigeria (Oviasojie *et al.*, 2013). The tree is also found growing wild in Ghana, Burkina Faso, Uganda, Sudan and some other West African Countries. In Nigeria, the tree also occurs in the wild and is commonly found in the guinea savannah belt or zone of the country as well as the lower Sahel ecology with an annual rainfall of 600-1300 mm (World Agroforestry Center, 2008) and totally absent in arid zones (Keay, 1989). According to Adegbehin and Omegeh (1993), the species is found scattered round farmlands in Niger State of Nigeria. The tree produces Shea notes which are used in the production of shea butter. The fruit pulp, being a valuable food source, is also taken for its laxative properties. Shea nut cake is used for cattle feed (Amalu, 1998), and is a delicacy, usually eating by children and women who are mainly involve in fruit and nut collection (Senjobi *et al.*, 2010; Ogunkunle and Eghaghara, 1992; Maranz *et al.*, 2004). The roots are used as chewing sticks in Nigeria, mostly in savannah areas (Isawumi, 1978); the husks make good mulch and fertilizer (FAO, 1988a). The distribution of the Shea tree in the guinea savannah of Nigeria is affected by climatic and soil factors.
According to Esu (2004), one of the strategies to achieve food security with sustainable environment is to study soil resources to details through soil characterization and land evaluation for various land utilization types. An analysis of soil physical and chemical

properties in Shea growing belt would therefore provide the necessary information that could be correlated with tree characteristics to study the distribution and the dynamic mix of the Shea tree in the guinea savannah ecology of Nigeria. Soils supporting the Shea tree have been variously studied in Nigeria and Ghana. Oviesogie *et al.* (2013), characterized soils supporting Shea tree in Ofiki and Konto-Karfi in Oyo and Kogi states, Nigeria. They reported a wide variation in topography, slope and general land form but similar chemical characteristics of the two locations. Osayande *et al.* (2014) studied the fatality status of a Shea field at Bida, Niger State, Nigeria and reported a low organic matter, ECEC and exchangeable Potassium status of the soils when compared with soil fertility classes for upland crop cultivation and soil characteristics for tropical soils. Abubakari *et al.* (2012) study soil characteristics in Shea parklands of Ghana and reported a strongly acid to natural soil pH, low level of organic matter, effective cation exchange capacity (ECEC) and total exchangeable bases. As was later observed by Osayande *et al.* (2014) in Nigeria, Abubakari *et al.* (2012), observed that in spite of the low pH, the soils of the parkland studied were highly base saturated (PBS> 80%) and concluded that deficiencies of basic cations were uncommon. Osayande *et al.* (2014), however cautioned that the high base saturation per cent observed in soils supporting Shea tree should not be relied upon as an indicator of soil fertility above as it values could be influenced by exchangeable sodium due to low rainfall amount that is characteristic of the Shea belt.

Where these studies are useful it must be pointed out that information generated from them are inadequate in recommending which areas are suitable for Shea tree domestication in Bida, Niger State where studies on soil characterization with respect to Shea tree cultivation are non-existence. It is against this backdrop that this research work was initiated to generate base line data and hence provide information on soil properties and characteristics of these soils. The objective of this study was therefore to, characterize and evaluate the soil physical and chemical properties in the study area for Shea tree cultivation.

MATERIALS AND METHODS

Description of the study area

This study was conducted at Kuchi along Jima road in Lavun Local Government area of Niger State. The area lies between latitude 9º 30'N and 30.10º 50' N and longitude 25' 57.61 and 6º 27' 2.00 E with an elevation of 106.4 m above sea level. It covers an area of about 3 hectares. Bida experience a bimodal pattern of rainfall that fall between April to October, with peaks in August and September. This is followed by a short period of dry season which is usually between Novembers to March. The study area has an average annual rainfall of 1000-1500 mm with a mean monthly relative humidity of between (30 and 93%) and temperature with a range of 27-34ºC (Nyagba, 1995). The type of land use is majorly annually cultivation small sizes of land for maize, cassava, yam, mango, Shea tree, and orange.

The vegetation

The study area falls within the southern guinea savannah vegetation belt of Nigeria. The overall vegetation consists of mainly tall grassland, shrubs and scattered trees mainly of economic importance; such as locust beans (*Pakia biglobosa*), Mango (*Magnifera Indica),* Shea tree (*Vitellera paradoxa), Daniella oliveri* (chiiha) and *Isoberlinia doka* (akovol) and orange (*Citrus spp). Vitellaria paradoxa* constitute the highest number of trees and shrubs in the area with an estimated distance of 25 m in between trees varied across the study area. The dominant grasses include *Andropogon gayanus, Tridas procumbens, Imperata cylindrical, Rottbollia cochinchinensis etc.* The land is cultivated to arable crops such as *Manihot species, Arachis hypogea, Dioscorea species, Vigna ungulate* and *Zea mays.*

Geology

In terms of geology, Bida formation comprised of three zones; the Southern part sand stone, the upper Bida sand stone and the western Bida sand stone which is found around the Bida Airport in Kuchi community were the study area is located consists of sand stones and mud rocks. They are micaceous throughout with mud rocks predominating. The sand stone in this

zone are generally fine to medium grained, moderately sorted such as micaceous and feldspathic. In some parts, there are calcareous, micaceous and shellys; various type of cement –like iron oxides, silica, carbonates and clay where shown to be present in the Bida sand stone. In terms of parent materials, the soils, were derived from the basement complex rock, the rock is fairly resistant to weathering as evidence from the presence of weather able minerals found in the profile.

Field study

An area of 3 hectares was chosen to represent the farming community. Soil morphological properties were observed and described in the field following the soil survey manual/method (Soil Survey Staff, 2010); based on texture, colour, soil depth, gravel content, consistence, drainage, presence or absence of plinthite or concretions and mottles. A total of 3 profile pits were dug and 13 soil samples were collected and put into labeled polythene bags and taken for laboratory analysis.

Soil Analysis

Soil samples were air-dried at room temperature pulverized to pass through a 2 mm sieve and analyzed using standard procedures. Samples were analyzed for physical and chemical properties as soil pH was determined in a 1:1 soil: water suspension using a pH meter (MMHE, AS 218, Germany) (Hendershot *et al.*, 1993). Particle size distribution was by Bouyoucs hydrometer method using Calgon as a dispersing agent (Gee and Or, 2002). Organic carbon was analyzed by the dichromate oxidation procedures (Nelson and Sommers, 1996). Total nitrogen was determined by the Miro-kjeldah method (Adaikwu *et al*., 1985). Available phosphorus was determined by Bray-1 method, (Anderson and Ingram, 1993). Exchangeable cations were extracted using NH_4 OAc buffered at pH7.0 (Thomas, 1982). Potassium (K) and Sodium (Na) were determined with a flame photometer (PFP – 7 model, manufactured in India and originated from digital distribution platform developed by electronic arts) while Exchangeable calcium (Ca) and Magnesium (Mg) were determined using Atomic Absorption Spectrophometer (Perkin Elmer 403, PFP – 7 model, manufactured in India and originated from digital distribution platform developed by electronic arts). Cations Exchange Capacity (CEC) was determined by the summation of the exchangeable cations (Prasad and Power, (1997).

RESULTS AND DISCUSSION

Climatic parameters and particle size distribution of the study area.

The climatic parameters and soil particle size distribution of the study area are presented in Table 1. The mean annual rainfall and temperature of the study area was 1450 mm and 28.1 ^{o}C respectively. Both parameters fell within acceptable rainfall and temperature requirements for Shea tree cultivation. According to Akintola (1986), rainfall and temperature ranges of 1300 – 1600 mm and 26.4 – 29.8^{o}C are adequate for Shea tree cultivation and growth. Oviasogie *et al*. (2013) cited (World Agro Forest Center Report) low rainfall ranges of 133 – 700 mm in Konto-Karfi (Kogi State) and 350 – 1100 mm in Ofiki, Oyo State as being within the biophysical limit (rainfall, temperature, and number of dry mouths) for Shea tree growing ecology in other parts of the world. Particle size distribution indicates that sandy soil was dominant in all the three profiles i.e. the sandy soil was very common in all the profile under study (Table 1). Clay soil was the second most common soil in the Shea parkland of the study area, silt soil was the least common and decreased with depth in all the profiles. The textural classes of the soils were sandy loam at the surface to sandy clay at the subsoil. This finding supports support conclusion by Hall *et al*. (1996) who observed that Shea tree thrive well on dry sandy soils that have good humus cover. The soils were well drained and characterized by plinthic materials at depth of 97 – 110 cm and 73 – 123 cm (Table 1). The chemical properties (Table 2) of the soils revealed that the soils were slightly acidic with pH value ranging from 5.47 – 6.13 and this decreased with depth; this observation corroborates with findings of Nwite and Nnoke (2005) who reported a general decrease in pH values in the lower profiles. Generally, the pH values were within the desirable range for plant nutrition. The value of organic carbon, Total nitrogen, Available phosphorus and exchangeable bases were low and

varied from one profile to another. The CEC values were generally low and ranged from 2.43-6.12 cmol/kg. the low values of CEC observed in the study area is in line with findings of Amakhian and Osemwota (2012), who reported low values of CEC in soils of Southern Guinea Savanna Zone of Nigeria. Profile A and B were classified as typic plinthustalf because of the presence of plinthic materials in the profiles at depth of 110 cm and 123 cm. (Soil Survey Staff, 2010). In FAO/UNESCO soil legend, the soils were classified as luvisols because of the presence of argillic horizon. Profile C was classified as plinthic luvisols. Under the soil order they are classified as Alfisols.

Table 1: Soil physical properties of soils of the study area

Profile Description	Annual rainfall	Temperature (°C)	Drainage	Depth (cm)	Sand ← %	Silt	Clay →	Textural class	Concretions
			Well drained	0-29	92.42	3.76	3.83	SL	
				29-39	88.41	5.71	5.88	LS	
A	1450	28.1^{0}C		39.63	83.96	7.28	8.76	SCL	
				63-97	71.94	9.22	12.64	CL	
				97-110	67.83	12.01	13.07	SC	Mn
			Well	0-23	92.36	3.28	6.86	SL	
B	1450	28.1^{0}C	drained	23-36	89.44	7.00	9.05	SL	
				36-73	86.66	9.28	11.08	SC	
				73-123	82.95	10.20	14.10	SC	Hardpan
			Well	0-22	94.96	3.28	6.86	SL	
C		28.1^{0}C	drained	22-34	83.95	7.00	9.05	SL	
	1450			34-84	68.94	9.28	11.08	SC	
				84-130	64.63	10.20	13.15	SC	

sandy loam, LS = loamy sand, SCL = sandy clay loam, CL = clay loam, SC = sandy clay, concretions = Mn, Hard pan.

Table 2: Chemical Properties of Soils of the Study Area

Profile Description	Depth (cm)	Soil pH (H^2O)	O.C	Total N	Avail. P	K^+	Ca^{2+}	Mg^{2+}	Na^+	CEC
				← g/kg(mg/kg) →			← Cmol/kg →			
	0-29	5.78	4.0	4.8	1.44	2.01	2.03	1.06	1.02	6.12
A	29-39	5.75	3.4	4.5	2.00	1.89	1.72	1.03	0.96	5.60
	39-63	5.66	2.6	4.1	1.40	1.60	1.43	0.90	0.86	4.86
	36-97	5.60	0.4	3.8	1.04	1.41	1.25	0.63	0.64	3.90
	97-110	5.47	0.2	3.3	1.01	0.99	1.01	0.49	0.43	2.92
	0-23	6.13	30.1	4.3	2.08	1.82	1.05	0.98	0.90	5.00
B	23-36	6.06	25.3	4.1	1.84	1.69	0.99	0.89	0.87	4.44
	36-73	6.00	24.2	3.8	1.36	1.48	0.79	0.66	0.59	3.52
	73-123	5.89	19.2	3.6	2.48	1.26	0.68	0.49	0.40	2.83
	0-22	5.84	26.1	4.4	2.16	1.66	0.94	0.89	0.96	4,45
C	22-34	5.79	15.4	3.9	2.12	1.48	0.86	0.77	0.88	3.99
	34.84	5.68	13.8	3.7	1.76	1.26	0.62	0.51	0.63	3.02
	84-130	5.54	13.2	3.2	1.28	1.09	0.47	0.39	0.43	2.43

CONCLUSION

The result indicated that climatic factors (rainfall and temperature) in the study area were in conformity with climatic requirement for Shea tree growing ecology in order part of the word. In terms of vegetation, the study area exhibited great similarities with *vitellaria paradoxa* constituting the highest number of trees and shrubs in the area. The soils had similar observable physical properties in terms of parent materials, texture and drainage. However, the chemicals properties responsibility for soil fertility were low but can be corrected by application of mineral fertilizer nutrients especially nitrogen, phosphorus and potassium. Alternatively, the use of organic manure such as cow dung and poultry dropping is recommended to improve the productivity of these soils.

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