Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.6, No.10, 2016
www.iiste.org

Biophysical Properties of Selected Areas of Delta State and Their Suitability Assessment for Coconut, Raphia and Oil Palms Cultivation

Osayande P. E.[1*] Orhue E. R.[2] Oneju A. A.[2] Oseghe D. O.[1] Maidoh F. U.[1] Irhemu P.[1]
1.Chemistry Division, Nigerian Institute for Oil Palm Research, P.M.B. 1030, Benin City, Nigeria
2.Department of Soil Science, Faculty of Agriculture, University of Benin, P.M.B. 1154 Benin City, Nigeria

Abstract
This study was conducted to provide information on the biophysical properties and Soil Suitability Assessment (SSA) of seven (Abbi, Agbor, Asaba, Bomadi, Ughelli, Sapele and Warri) locations in Delta state, Nigeria. Composite top and subsurface soil samples were obtained from 0-45 cm and 45-90 cm depths, air dried, sieved through a 2 mm sieve and analyzed for physical and chemical properties using standard laboratory methods. Mean values of the physical and chemical properties of the seven locations were compared and marched with the guidelines provided by FAO framework for rainfed agricultural crops and manual for land suitability evaluation of agricultural crops. The suitability class (aggregate suitability) was determined by most limiting characteristics of that parameter. Results indicated that three (3) out of the seven locations of Delta state are not suitable (N) for the cultivation of Oil palm with limitation being the sandy texture of sub soils. The locations are all however suitable for the cultivation of Coconut and Raphia palms. On aggregate basis, the locations are classified as N (not suitable) for the cultivation of the palms with limitation being the fertility status of the soils but can be corrected. Fertility measures to improve the soils of these locations in Delta state for the cultivation of these economic palms have been suggested.
Keywords: Biophysical properties, Coconut Palm, Oil Palm, Raphia palm, Soil Suitability Assessment (SSA).

1.0 INTRODUCTION:

Biophysical properties of an area according to FAO (1976) include information on climate, hydrology, topography, soils, land cover and vegetation. These properties clearly combine to determine the type and amount of vegetation present in an area. With respect to crop production, climate and soil have been identified as two major factors of the biophysical property of an environment that determine the cultivation and yield of any crop (Oviasogie *et al*., 2011). These two properties have greatly combined to confine the cultivation of some of the economic palms such as Oil palm (*Elaeis guineesis* J.), Coconut palm (*Cocos nucifera* L.) and Raphia palms (*Raphia spp*) to the wetter areas of Southern Nigeria (Remison, 2004).

Coconut and oil palms are two of the most important oil crops in the world. In comparison with Raphia palms both also provide the three basic needs of man which are food, clothing and shelter. While coconut is fondly called the "tree of life", oil palm is referred to as the "golden tree." The soils supporting both palms have been variously studied. Oil palm thrives in deep soils that are not normally waterlogged. Coconut palms on the other hand can thrive in waterlogged soils provided that the soils are sandy and not marshy while Raphia *hookeri* which is the most economic of the twenty species of Raphia palms that are known thrive in both waterlogged and marshy soils. The three palms no doubt require soils with adequate fertility and free from concretions and hard pans. Accumulation of free iron in the horizons of soils is known to result in the formation of concretions, nodules and plinthites, (Obi *et al*., 2009; Osayande *et al*., 2013).

Soil Suitability Assessment (SSA) of a crop is the determination of the minimum properties of a soil that can limit the cultivation of that crop. Soil suitability assessment for oil palm and indeed for all of the other economic palms is based on those physical and chemical properties such as soil pH, total nitrogen, organic matter content and effective cation exchange capacity.

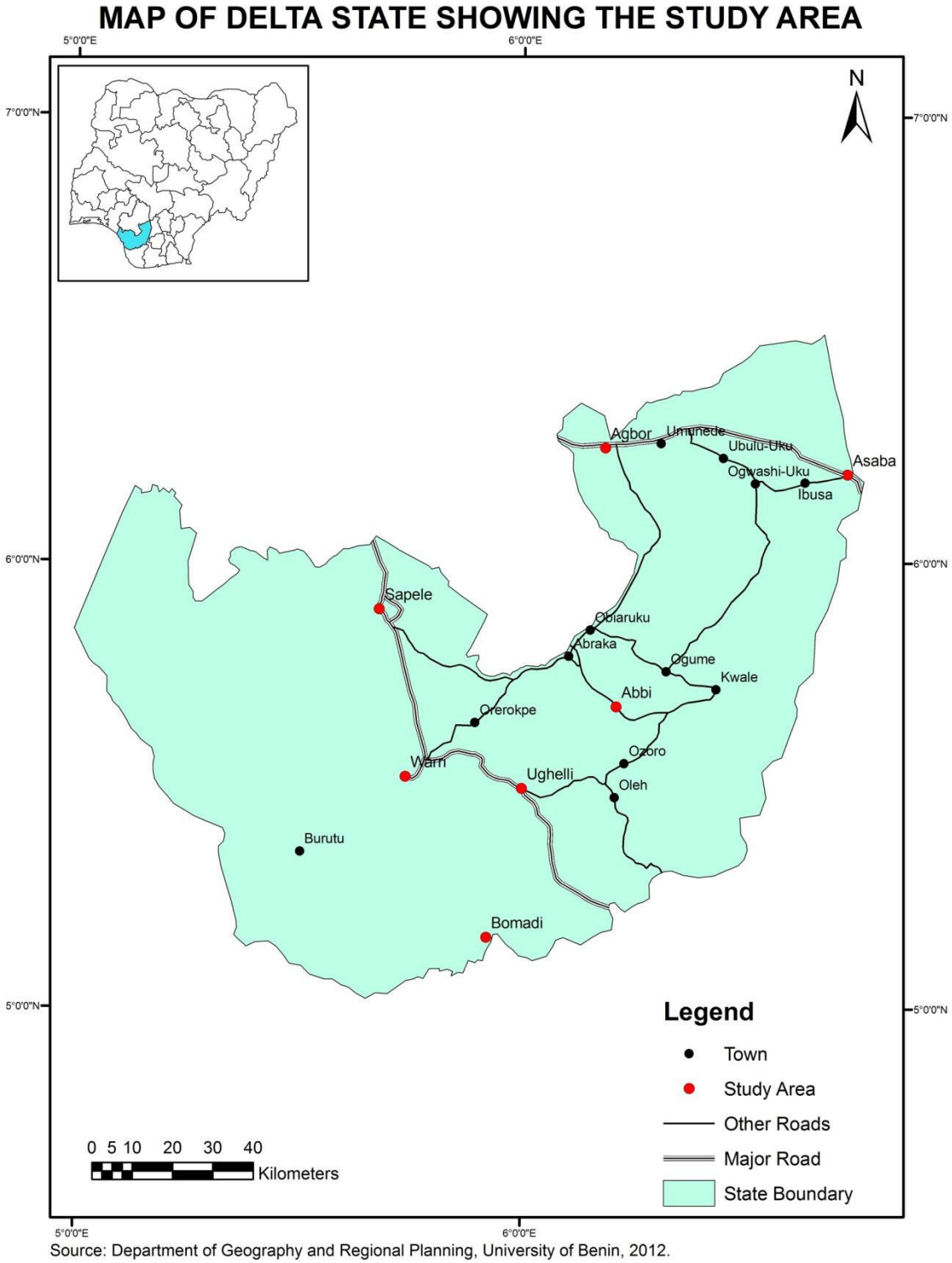
The objective of this study therefore was to ascertain the biophysical properties of these selected areas of Delta state and ascertain their suitability for the cultivation of coconut, raphia and oil palms using determined physical and chemical properties as indices for suitability.

2.0 MATERIALS AND METHODS

2.1 Study area

This study was carried out in seven locations of Delta state which are Abbi defined on Latitude 5^0 42'N and Longitude 6^0 17' E, Agbor (Latitude. 6^0 41'N, Longitude. 6^0 64'E), Asaba (Latitude 6^0 11'.23''N, Longitude 6^0 41' 13.21''E), Bomadi on Lat 5^0 76'N and Longitude 5^0 64' E, Sapele (Lat. 5^0 52' N, Long 5^0 37' E), Ughelli (Latitude 5^0 30' N, Longitude 5^0 57'E) and Warri (Latitude. 5^0 24'N, Longitude 5^0 11' E). Delta State is generally low-lying without remarkable hills. The State has a wide coastal belt inter-laced with rivulets and streams which form part of the Niger-Delta. It has two distinct seasons, the rainy season which starts in late

March and ends in early November and a short dry season which starts in late November till early March. There is a short break in August. Temperature ranges from a minimum of 21^0 C to 32^0 C with a mean of 25^0 C. Annual Rainfall ranges between 2300 mm to 3000 mm (Remison, 2004).The vegetation of the sampled sites were cassava (Manihot *esculenta*) and maize (Zea *may*) and some scattered elephant grasses. The location and soils of the sampled areas in Delta state are illustrated in figure 1.



Source: Department of Geography and Regional Planning, University of Benin, 2012.

Fig 1: Map of Delta State showing sampled areas.

2.2 Soil sampling and laboratory analysis:

Composite soil samples were randomly collected with the aid of a soil auguer at two depths to depict top and sub soils in all the locations, air dried in the laboratory and analyzed as follows: Particle size distribution was

determined by the hydrometer method (Gee and Or, 2002). Organic carbon was determined by the dichromate wet oxidation method of (Walkley and Black, 1934). Available phosphorus (P) was determined by Bray P-1 method (Anderson and Ingram, 1993). Total nitrogen (N) was determined by macro Kjedahl method (Brookes *et al*., 1985). Soil pH was determined in a 1:1 soil to water suspension using a pH meter (Hendershot *et al*., 1993). Exchangeable bases were extracted using NH_4OAC buffered at pH 7.0 (Thomas, 1982). Potassium and sodium were measured by flame photometer while calcium and magnesium were determined using atomic absorption spectrophotometer.

2.3 Soil suitability assessment (SSA):

Mean values of the physical and chemical properties of the various locations were compared and marched with the guidelines provided by FAO (1976) framework for rainfed agriculture and Djaenudin *et al*., (2003) manual for land suitability evaluation of agricultural crops. The suitability class (aggregate suitability) was determined by most limiting characteristics of that parameter. The limitation method operates with the principles of the law of minimum which states that performance is always determined by the least favourable factor.

3.0 RESULTS AND DISCUSSION:

3.1 Biophysical properties of the sampled locations:

The biophysical properties which represent information on climate, hydrology, topography, soils (nature of soil texture) land cover and vegetation of the studied locations are shown in Table 1. The land was generally flat in all the locations. There were absence of structural impediments such as gravel, stones, mottles and rooting depth was greater than 90 cm. With respect to soils (nature of soil texture), hydrology and topography, Abbi, Asaba and Sapele were classified as S1 (Highly suitable) for the cultivation of Coconut and Raphia palms with limitation being the sandy texture of sub-soils and N (not suitable for the cultivation of oil palm). These characteristics are similar to water inundation, low nutrient, moderately well- drained and sandy texture of sub soils. The second and third characteristics for hydrology, soils (nature of soil texture) and topography which are low nutrient, poor soil drainage with $> 4^0$-7^0 and $>15^0$ gradient respectively (Table 1) puts the cultivation of Coconut, Oil and Raphia palms at S2 (moderately suitable) for Bomadi soils and S3 (marginally suitable) for Agbor, Warri and Ughelli soils with limitation being poor soil drainage. With respect to climate (rainfall, temperature and duration of dry season) none of the locations was highly suitable with limitation being duration of dry season. Six of the seven locations which are Abbi, Agbor, Asaba, Bomadi, Ughelli and Warri are classified as S2 (moderately suitable) for the cultivation of Coconut, Oil and Raphia palms while Sapele was marginally suitable (Table 1). However, the locations are classified as S1 for the three palms when marched with rainfall and temperature requirements for the palms (Table 1). Sys (1985) put the minimum rainfall requirement for oil palm at 1700 mm while Djaenudin *et al*., (2003) and FMNAR (1990) put the rainfall and temperature requirements for coconut, oil and Raphia palms at 2500 mm and 25^0 C respectively.

3.2 Chemical properties of the selected soils of Delta state and suitability for Coconut, Oil and Raphia palms:

The soil pH of Abbi and Sapele soils had moderate acidity with mean soil pH of 5.82 and 6.21 at 0-45 cm and 45-90 cm respectively in Abbi soils while Sapele had mean soil pH of 6.47 and 6.53 at 0-45 cm and 45-90 cm respectively. The other locations, Agbor, Asaba, Bomadi and Ughelli were slightly acidic in soil pH except Warri which had neutral soil pH with mean soil pH of 7.02 and 7.18 at 0-45 cm and 45-90 cm respectively. Generally, soil pH of the soils decreased with increasing soil depth (Table 2). With respect to suitability for Oil, Coconut and Raphia palms, Abbi soils were classified as S1 (highly suitable) in terms of soil pH for the cultivation of Coconut and Raphia palms and S3 (marginally suitable) for the cultivation of Oil palm. Agbor, Asaba, Bomadi and Ughelli soils were classified as S1 (highly suitable) for the cultivation of Coconut, Oil and Raphia palms. Sapele soils were classified as S3 (marginally suitable) for the cultivation of Coconut and Oil palms but classified as S1 (highly suitable) for the cultivation of Raphia palms while Warri soils were classified as N (not suitable) for the cultivation of any of the palms in terms of soil pH but can be corrected. The locations were N (not suitable) in terms of organic matter, nitrogen, phosphorus and cation exchange capacity (CEC) for the cultivation of Coconut, Oil and Raphia palms. On aggregate basis, the locations were highly suitable for the cultivation of Coconut and Raphia palms but marginally suitable for the cultivation of Oil palm but can be corrected.

4.0 CONCLUSION:

Three out of the seven locations of Delta state currently assessed for its biophysical properties and suitability for Coconut, Oil and Raphia palms are not suitable for the cultivation of Oil palm with limitation being the sandy texture of sub soils. Based on this limitation, Ughelli and Warri are moderately suitable for the cultivation of Oil palm while the locations are all suitable for the cultivation of Coconut and Raphia palms. On aggregate basis, the

locations are classified as N (not suitable) for the cultivation of the palms with limitations being fertility status of the soils but can be corrected. Application of gypsum ($CaSO_4$) is suggested in Warri soils to reduce the soil pH to the desirable moderate acidic levels. Generally, the locations would need measures that enhance the build up of the soil organic matter content and nutrient holding capacity of the soils, specifically the cation exchange capacity (CEC). Thus the use of composted Oil Palm Empty Fruit Bunch (EFB) is suggested as a way of improving CEC and organic matter content of the soils.

REFERENCES

Anderson, J.M. and Ingram, J.S.L. (1993). Tropical Soil Biology and Fertility; A Handbook of Method of Analysis *International Wallingford,* UK, 38-39

Brookes, P.C.; Landman, A.; Prudes, G and Jenkenson, D.S. (1985). Chloroform Fumigation and Release of Soil Nitrogen; a rapid extraction method to measure microbial biomass and Nitrogen in Soil. Soil Biology and Biochemistry. 17: 837-842.

Djaenudin D., Marwan H., Subagjo H., Hidayat dan A. (2003). Manual for land suitability evaluation of agricultural crops. Balai Penelitian Tanah (ISRI), Puslitbang Tanah dan Agroklimat Bogor (Indonesia-version)

FAO, (1976). A framework for land evaluation. *Soils Bulletin* 32. FAO Rome. Vii + 72 pp

Federal Ministry of Agriculture, Water Resources and Rural Development, FMANR 1990. *Literature Review on Soil Fertility Investigations in Nigeria* Bobma Publishers, U.I., Ibadan. PP 256.

Gee, G. W. and Or, D. 2002. Particle size distribution. In: Dane J.H and Topp. G.C. (eds). Methods of soil Analysis. Part 4, Physical methods. Soil Sci. Am Book Series No.5, ASA and SSSA, Madison, W.I. PP 255-293.

Hendershort, W.H., Lalande, H., Duquette, M. (1993). Soil reaction and exchangeable acidity. In: Carter M.R. (ed). Soil Sampling and methods of soil analysis. Canadian Soc. Soil Sci. Lewis Publishers, London, PP 141-145.

Obi, J.C.; Akinbola, G.E. and Anozie H.F. (2009). Distribution of dithionite and oxalate-extractable iron oxides of a catena in the basement complex soils of Southwestern Nigeria. *Nigerian Journal of Soil Science* 19:100-108

Osayande P.E., Oviasogie P.O., Aisueni N.O., Stephen O., Irhemu P and Ekebafe M.O. (2013). Assessment of Dithionite and Oxalate Extractable Iron and Aluminium Oxides in Soils Supporting Raphia palms (*Raphia spp)* at NIFOR Main Station. *Nigerian Journal of soil science*. 23 (2): 1-10.

Oviasogie, P.O., Aisueni N.O., Oko-Oboh E., and Stephen O. (2011). Land use and biophysical properties in relation to Elaeis *guineesis* and Hevea *brasiliensis* estabilishment. *Nigerian Journal of Life Science* 1(2) : 135-140

Remison, S.U.(2004). Agriculture as the way. Ambik press, Benin City. 73 PP

Sys C. (1985). Land evaluation. State University of Ghent, International Training Centre for Postgraduate Soil Scientists, part I, II and III. Ghent.

Thomas, G.W. (1982). Exchangeable cations. In: Page A.L. *et al* (eds). Methods of Soil Analysis part 2. *Agron. Monigr* 9. Wisconsin 3rd edition. *ASA* and *SSSA* Madison, pp 159-165.

Walkley, A. and Black L. A. (1934). Determination of organic carbon in soils. *Soil Sci.J.* 37(1): 29-38

Table 1: Biophysical properties of the sampled locations

Limiting Biophysical Factor (soils, hydrology and topography)	Suitability class for economic palms	Location suitable for soils, hydrology and topography.	Limiting Biophysical Factor ((Climate: (Rain fall, temperature & duration of dry season))	Suitability class for economic palms	Location suitable for Climate: (Rain fall, temperature & duration of dry season))	Limiting Biophysical Factor (Land Cover and vegetation)	Suitability class for economic palms	Locations suitable for land cover and vegetation
Low nutrient, sandy texture of sub soils & < 3^0 gradient	S1 Coconut Raphia palm	Abbi Asaba Sapele	Rain fall: 2000 mm - 2500mm. Temperature: > 25^0 -28^0 C < 1 month of dry season	S1 Oil palm Raphia palm Coconut	Nill	Anthropogenic vegetation (Year-round multilayered cover of vegetation on leveled area only slightly inclined with cohesive soil layer	S1 Coconut Oil palm Raphia palm	Abbi Agbor Asaba Bomadi
Water inundation, low nutrient, moderately well drained, sandy texture of sub soils with 4^0-7^0 gradient	S2 Coconut Raphia palm	Bomadi	Rain fall: 1500 mm – 2000 mm. Temperature: > 22^0 -23^0 C 1-2 month of dry season	S2 Oil palm Raphia palm Coconut	Abbi Agbor Asaba Bomadi Ughelli Warri	Secondary forest (Temporary incomplete cover of vegetation	S2 Coconut Oil palm Raphia palm	Warri Ughelli Sapele
Low nutrient, poor soil drainage with > 15^0 gradient.	S3 Coconut Oil palm Raphia palm	Agbor Warri Ughelli	Rainfall: 1250 mm-1500 mm Temperature: 20-21^{0}C 4-5 month of dry season	S3 Oil palm Raphia palm Coconut	Sapele	Temporary extreme incomplete cover of vegetation on predominantly medium inclined leveled area with less cohesive soil layer	S3 Coconut Oil palm Raphia palm	Nill

S1 = Highly Suitable, S2 = Moderately Suitable, S3 = Marginally Suitable

Table 2: Particle size distribution of soils of selected areas of Delta State

Location	Depth (cm)	Sand	Silt (g/kg)	Clay	Textural Class
Abbi	0-45	865.30	48.70	88.00	Sand
	45-90	837.30	30.70	132.00	Sand
LSD(0.05)		17.21	17.91	Ns	
Agbor	0-45	848.00	46.00	106.00	Sand
	45-90	836.00	27.30	136.00	Sand
LSD(0.05)		5.74	11.74	Ns	
Asaba	0-45	844.70	45.30	110.00	Sand
	45-90	808.70	34.70	156.70	Sand
LSD(0.05)		17.91	Ns	Ns	
Bomadi	0-45	844.70	45.30	110.00	Sand
	45-90	808.70	34.70	156.70	Sand
LSD(0.05)	17.91	17.91	Ns	Ns	
Sapele	0-45	876.70	46.70	76.00	Sand
	45-90	840.00	36.00	124.00	Sand
LSD(0.05)		10.34	Ns	Ns	
Ughelli	0-45	762.67	42.70	194.70	Sandy loam
	45-90	740.67	24.00	235.30	Sandy loam
LSD(0.05)		10.34	10.34	Ns	
Warri	0-45	774.00	49.30	176.70	Sandy loam
	45-90	745.33	29.30	225.30	Sandy loam
LSD(0.05)		5.74	8.61	Ns	

Table 3: Chemical properties of selected areas of Delta State

Location	Depth (cm)	pH (H_2O)	O.C. (g/kg)	N	P	Ca	Mg	K	Na	CEC
						cmol/kg				
Abbi	0-45	5.82	8.74	0.89	6.38	1.62	0.55	0.35	0.03	2.55
	45-90	6.21	4.94	0.76	6.04	1.84	0.59	0.44	0.03	2.90
	LSD(0.05)	NS	0.69	0.07	NS	NS	NS	NS	NS	
Agbor	0-45	5.05	7.92	1.17	10.54	0.86	0.38	0.06	0.02	1.32
	45-90	5.55	4.55	0.63	5.89	0.97	0.45	0.34	0.02	1.78
	LSD(0.05)	NS	1.78	0.14	1.56	NS	NS	NS	NS	
Asaba	0-45	5.25	8.90	1.17	5.05	0.80	0.44	0.05	0.02	1.31
	45-90	5.53	4.67	0.63	5.88	0.85	0.50	0.07	0.02	1.44
	LSD(0.05)	NS	1.87	0.14	NS	NS	NS	NS	NS	
Bomadi	0-45	5.17	10.26	1.46	5.41	0.96	0.47	0.30	0.02	1.75
	45-90	5.48	3.16	0.60	4.38	1.02	0.51	0.25	0.03	1.81
	LSD(0.05)	NS	NS	0.59	NS	NS	NS	NS	NS	
Sapele	0-45	6.47	7.65	5.77	4.64	1.80	0.53	0.04	0.03	2.40
	45-90	6.53	6.76	3.99	2.88	1.73	0.55	0.03	0.02	2.33
	LSD(0.05)	NS	0.98	1.25	0.97	NS	NS	NS	0.007	

Table 3: Chemical properties of the selected soils of Delta state contd

Location	Depth (cm)	pH	O.C	N	P (mg/kg)	Ca	Mg	K	Na CEC
			g/kg			cmol/kg			
Ughelli	0-45	5.37	16.36	0.96	6.53	0.04	0.98	0.49	0.011.52
	45-90	5.50	12.07	0.73	5.41	0.08	1.05	0.45	0.02 1.6
	LSD(0.05)	NS	2.67	0.17	0.95	NS	NS	0.04	NS
Warri	0-45	7.02	7.77	1.81	10.18	0.31	3.52	0.49	7.7712.09
	45-90	7.18	3.64	0.66	5.22	0.61	3.89	0.21	3.648.35
LSD(0.05		NS	0.96	0.21	1.05	0.26	0.96	NS	NS

NS = Non significance