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Soil Nutrient Status of the Fresh Water Swamp at the NIFOR Raphia Hookeri Outstation, Otegbo

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Abstract:
Soil nutrient status of the Fresh Water Swamp at the NIFOR Raphia *hookeri* outstation, Otegbo was studied. Samples were obtained from mini pits sunk at two plantations in the study area. The collected samples were air-dried at room temperature for seven days and analyzed for physico-chemical properties in the laboratory using standard methods. The results showed that clay increased significantly with increased depth in both plantations while sand decreased significantly with increased depth in both plantations. Silt however decreased significantly with increased depth in plantation 1 and decreased not significantly with increased depth in plantation 2. The silt/ (silt + clay) ratios were all less than unity. Soil nutrient status was generally low as revealed by their estimated levels of availability. Organic carbon, Nitrogen and Phosphorus decreased with increased depth. Though Potassium was the same at both the top and subsoil in plantation 1, it however decreased not significantly with increased depth in plantation 2 Mean soil pH of between 5.55 in the top soil and 5.85 in the subsoil seemed optimum as revealed by the positive and significant correlation of soil pH with ECEC with ($r = 0.803$, $p < 0.01$) and negative correlation of ECEC with soil pH between 5.47 in the top soil and 5.61 in the subsoil with $r = -0.286$ in plantation 2. This study however revealed that the Fresh Water Swamp soil nutrient status can be improved for Raphia *hookeri* cultivation by appropriate soil organic matter management as well as enhanced sand and silt weathering.
Key words: Fresh water swamp, NIFOR, Raphia *hookeri*, Otegbo.

1.0 Introduction:

Fresh water is defined as water having a low salt concentration- usually less than 1%. Plants and animals in fresh water regions are adjusted to the low salt content and do not usually survive in areas of high salt concentration. Swamps on the other hand are defined as wetlands whose dominant vegetation is comprised of woody plants such as trees and shrubs and the water may be anywhere from a few inches to over a foot deep. Though swamps are usually saturated with water during the growing season, they may dry out in the heat of a long dry season. The soil saturation in swamps creates a diversity of vegetation that is completely adapted to this hydromorphic soil conditions. Raphia palms (*Raphia spp*) are examples of such plants that are perfectly adapted to such hydromorphic soil conditions. Though there are eleven (11) genera of the palms, only five of them are tapped for wine and *Raphia hookeri* is the highest yielder of palm sap (Otedoh, 1981). The sap plays a major role in the economic life of the people of West Africa especially in Nigeria where the wine is required in almost all traditional functions. The Nigerian Institute for Oil Palm Research which has a mandate to provide the much needed research information on the palms currently bottles the wine for safe consumption. Such regular productions in terms of tapping deplete the soils of such nutrients needed for sustainability of such future productions. Akpabio *et al* (2012), reported 55.31mg/100g, 26.60 mg/100g, 23.63 mg/100g, 20.95 mg/100g, 8.54mg/100g, 4.77 mg/100g, 4.57 mg/100g for calcium, magnesium, sodium, potassium, manganese, cobalt and iron respectively for mineral element composition of exudates of *Raphia hookeri*. This high nutrient removal from the soil as a result of tapping calls for constant study to determine the physico-chemical properties and suggest management methods where desirable.

2.0 MATERIALS AND METHODS

2.1 Study area:

The study was conducted at the NIFOR outstation, Otegbo located just outside Warri in Delta State. It lies on Latitude $5^0 25'$ and Longitude $5^0\ 34'$The locations covered the humid and sub-humid with mean annual rainfall of 3000 to 4000mm. Temperature ranges from a minimum of 21^0C to 32^0C with a mean of 25^0C. There are two distinct seasons, the dry season (November to March) and rainy season (March to October) and a short dry break in August.

2.2 Field study:

Twelve mini pits sunk in two *Raphia hookeri* plantations were used for the study. The mini pits measured 60cm

X60cm X120cm and two samples were collected from each pit, making a total of twenty four samples.

Laboratory study

The samples were then taken to the laboratory for studies on physico-chemical properties of the soils. The soil samples were air-dried at room temperature for seven (7) days and sieved with a 2mm sieve. The sieved samples were analyzed for physico-chemical properties as follows: Particle size was determined by the hydrometer method (Gee and Bander, 1986). Organic Carbon was determined by the dichromate wet oxidation method (Walkley and Black, 1965). 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 (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, Hydrogen and Aluminium (H^+ + Al^{3+}) was by titration method (Anderson and Ingram, 1993) while effective cation exchange capacity (ECEC) was determined by summation of exchangeable cations and exchangeable acidity (Tan, 1996)

3.0 RESULTS

The result of the particle sizes are shown in Table 1. Table 2 shows the chemical properties of the sampled plantations while Tables 3 and 4 show the correlation coefficient (r) between physico-chemical properties of both plantations.

Clay was significantly higher at the 60-120cm depth in both plantations, indicating a downward movement down the soil profile. Silt and sand were however higher at 0-60cm depth in both plantations. The silt/(silt+clay) ratios were less than unity indicating a fast rate of silt weathering into clay. This low silt/(silt+clay) ratios were also observed by (Aghimien 1982) and later Imogie *et al* (2008) in their study of Raphia hookeri supporting soils in NIFOR substation at Onuebum in Bayelsa state.

The soil pH was slightly acidic and ranged from 5.41 to 6.29 with a mean of 5.7 in plantation 1 and ranged from 5.35 to 6.31 with a mean of 5.5 in plantation 2. There was no significant difference in pH at both depths in plantation 2. However, the soil pH was significantly higher at 60-120cm depth in plantation 1. Organic carbon was low in both plantations having mean values of 4.23g/kg and 3.81g/kg respectively. Organic carbon decreased significantly with increased depth in both plantations. Nitrogen and Phosphorus were also low in both plantations. Nitrogen had mean values of 0.29g/kg and 0.26g/kg in plantations1 and 2 respectively. Phosphorus had 3.65mg/kg and 3.87mg/kg in plantations 1 and 2 respectively. Nitrogen and Phosphorus decreased significantly with increased depth in both plantations.

Exchangeable potassium was low and was not significantly different at both depths. Calcium was also low but increased significantly with increased depth. Magnesium was medium and also increased significantly with increased depth. Sodium was high though not high enough to cause puddling and also increased significantly with increased depth. ECEC was low but increased significantly with increased depth. Base Saturation percent was medium and decreased non significantly with depth.

4.0 DISCUSSION:

The soils had high sand content but low silt and clay contents. The silt / (silt+clay) ratios were low, being less than unity in all the samples indicating that most of the silts have weathered into clay. According to Stewart *et al*., (1970), low silt and low silt /(silt + clay) ratios are indicators of advanced weathering which arises from prolonged action or strong intensity of the weathering agents such as rainfall, sunshine and biosphere. The soil system seemed to place more emphasis on the control and behaviour of the nutrients rather than availability as most of the available nutrients were low. For example, the soil pH was positively and significantly correlated with ECEC and calcium in plantation1, with ($r= 0.803$, $p<0.01$); ($r = 0.854$, $p< 0.01$) but was negatively correlated with the same ECEC and calcium in plantation 2 with ($r = -0.286$ and -0.433 respectively. The soil pH also had a negative but significant correlation with sand in plantation 1 with ($r = -0.672$, $p<0.05$) but had a positive and significant correlation with the same sand in plantation 2 with ($r = 0.582$, $p< 0.05$). Organic carbon however controlled the chemistry of the soils of both plantations with positive and significant correlations obtained between Nitrogen, Phosphorus Potassium and sand with ($r = 0.990$, $p< 0.01$); ($r= 0.829$, $p< 0.01$); ($r = 0.602$, $p< 0.05$) and ($r = 0.587$, $p<0.05$) in plantation 1 respectively. Organic carbon also had direct relationships with Calcium, Magnesium, ECEC and Silt with r 0.460, 0.413, 0.480 and 0.029 in plantation 2 respectively. This trend continued in plantation 1 with Organic carbon having positive and significant correlation with Nitrogen ($r = 0.988$, $p<0.01$). It also had direct relationships with P and sand of plantation 1 with $r = 0.192$ and 0.475 respectively. Its role as nutrient control in these soils was further buttressed by the positive correlation of sand with Nitrogen with $r = 0.568$. Sand also had a positive and significant correlation with Phosphorus of the same plantation 1 with ($r = 0.772$, $p<0.01$). Furthermore, Organic carbon, Nitrogen and Phosphorus decreased significantly with increased depth in both plantations. This observation probably suggests that organic matter supplied much of the Nitrogen and Phosphorus needed by *Raphia hookeri* palms. This may also mean that *Raphia hookeri* palms are top soil feeders; rapidly taking up those nutrients that are in great demand at the top soil (0-30cm) such that such nutrients begin to decrease with increased depth.

5.0 CONCLUSION:

This study revealed that Organic carbon and sand are important soil properties in hydromorphic soils supporting *Raphia hookeri*. Though other factors such as temperature and rainfall are *sine qua non* in the business of crop production, adequate management of the organic matter status and enhanced sand weathering in these soils will go a long way to sustaining *Raphia hookeri* cultivation in the Fresh Water habitat of Nigeria.

Further investigations are however needed to account for reasons for the decrease in Organic carbon, Nitrogen and Phosphorus with increased depth in both plantations.

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TABLE 1: PARTICLE SIZE DISTRIBUTION OF OTEGBO SOILS

Otegbo	Depth (cm)	Clay (g/kg)	Silt (g/kg)	Sand (g/kg)	Silt/ Silt+Clay	Textural Class	FAO Classificatn
Plantation 1	0-60	13.50	22.33	964.20	0.62	SandyClayL	Medium
	60-120	56.00	17.33	926.70	0.24	Clay	Fine texture
	LSD(0.05)	19.90*	4.20*	18.99*			
Plantation 2							
	0-60	10.00	25.80	964.20	0.72	Loamy sand	Medium
	60-120	37.30	22.70	940.00	0.37	Sandy clay	Medium
	LSD(0.05)	18.49*	10.16**	20.30*			

*Sig
**NS
*SandyClayL = Sandy Clay Loam.

TABLE 2 CHEMICAL PROPERTIES OF OTEGBO SOILS

Depth(cm) Otegbo	pH	O.C. (g/kg)	N (g/kg)	P (mg/kg)	K (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)	Na (cmol/kg)	ECEC (cmol/kg)	B.S %
Plantation 1 0-60	5.55	6.45	0.46	4.85	0.04	0.65	0.36	0.14	1.74	68.60
60-120	5.85	2.02	0.12	2.45	0.04	0.95	0.39	0.16	2.49	55.70
LSD(0.05)	0.15*	4.73*	0.29*	1.58*	0.01**	0.29*	0.37*	0.02*	0.28*	23.42**
Plantation 2										
	5.61	5.22	0.36	5.54	0.05	0.73	0.41	0.18	1.87	84.90
0-60	5.47	2.40	0.16	2.20	0.03	0.67	0.37	0.17	1.77	70.40
60-120	0.48**	1.29*	0.12*	1.14*	0.03**	0.18**	0.09**	0.02**	0.33**	35.55**
LSD(0.05)										

*Sig
**NS (Not significant)
O.C. = Organic carbon
ECEC = Effective cation exchange capacity, B.S. = Base saturation.

Table 3: Matrix of correlation coefficient of physico-chemical properties of plantation 1

Var.	pH	O.C.	N	P	K	Ca	Mg	S	ECEC	Clay	Silt	Sand
pH	-	-0.320	-0.379	-0.572	-0.124	0.854**	0.390	0.385	0.803**	-0.541	-0.186	-0.672*
O.C		-	0.988**	0.192	-0.246	-0.275	-0.008	-0.640*	-0.586*	-0.373	-0.259	0.475
N			-	0.314	-0.235	-0.345	-0.021	-0.625*	-0.672*	-0.488	-0.146	0.568
P				-	-0.046	-0.523	0.120	-0.228	-0.677*	-0.885**	0.676*	0.772**
K					-	-0.98	0.060	0.173	0.141	0.308	0.410	-0.446
Ca						-	0.061	0.110	0.703*	0.629*	-0.209	-0.623*
Mg							-	0.364	0.226	0.091	0.326	-0.188
S								-	0.404	0.386	0.301	-0.500
ECEC									-	0.859**	-0.301	-0.847**
Clay										-	-0.416	-0.968**
Silt											-	0.176
Sand												-

*Correlation is significant at the 0.05 level
**Correlation is significant at the 0.01 level.

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Table 4: Matrix of correlation coefficient between Physico-chemical Properties of Plantation 2

Var.	pH	O.C.	N	P	K	Ca	Mg	S	ECEC	Clay	Silt	Sand
pH	-	0.005	0.079	0.212	-0.438	-0.433	-0.089	-0.218	-0.286	-0.541	-0.037	0.582*
O.C		-	0.990**	0.829**	0.602*	0.460	0.413	-0.233	0.480	-0.566	0.029	0.587*
N			-	0.834**	0.544	0.390	0.344	-0.280	0.432	-0.561	0.011	0.587*
P				-	0.631*	0.319	0.162	-0.348	0.220	-0.712**0.318	0.646*	
K					-	0.450	0.344	0.125	0.597*	-0.089	0.356	-0.022
Ca						-	0.196	-0.160	0.506	-0.321	0.417	0.202
Mg							-	0.545	0.731**	-0.054	-0.442	0.201
S								-	0.445	0.395	-0.370	-0.295
ECEC									-	0.074	-0.181	-0.019
Clay										-	-0.312	-0.951**
Silt											-	0.003
Sand												-

*Correlation is significant at the 0.05 level

**Correlation is significant at the 0.01 level.