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FERTILITY INDICES AND MANAGEMENT OF HYDROMORPHIC SOILS SUPPORTING RAPHIA PALM (*RAPHIA HOOKERI)* MANN AND WEND LAND) PLANTATION AT ONUEBUM, BAYELSA STATE, NIGERIA.

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ABSTRACT
Fertility status of soils supporting *Raphia hookeri* at Onuebum in Bayelsa State, Nigeria, was investigated. The soils have silt / (clay + silt) ratios very low, being less than unity in all the samples which is an indication that most of the silt has been weathered into clay. The soils pH were moderately to strongly acidic with their values ranging from 4.50 - 4.52. The hydromorphic soils supporting the growth of *Raphia hookeri* palms contained low concentration of total N, available P and relatively low exchangeable cations, Ca, Mg, K and Na. The base saturation percent is medium to high (66.0 – 81.0%) and low in effective cation exchange capacity (4.754 – 6.416 cmol / kg $^{-1}$). The plantation therefore require application of organic or inorganic fertilizer preferably N and K to boost the soil nutrient. In addition, good tillage and liming should be done to reduce the flooding and acidity of the soils.

KEY WORDS: *Raphia hookeri*, Chemical properties, management, fertility status, supporting.

INTRODUCTION

Raphia palm is monocotyledonous tree crop that thrives on predominantly swampy areas which are mostly hydromorphic soils. It is a utility plant that supplies numerous products of social and economic importance especially in Southern Nigeria. The palms valued for their fibre (piassava), furniture materials, and cosmetic by products, and palm sap called palm wine, which is rich in vitamins, carbohydrates and yeast (Obahiagbon, 2007). Major constraints to crop production in tropical Africa generally include biotic and abiotic factors. Among the biotic factors is the soil. Soil is the major contributor to crop yield, this is because conducive soil factors supply enough plant nutrients which are essential for the growth, development and yield of crops. Thus soil testing is essential to the determination of the potentials and constraint of soils to crop.

In order to fully exploit raphia palm, there is need to know the soil properties of the hydromorphic soil on which the palm grows and how it can be properly managed for optimal growths, development and yield. Hydromorphic soils are characterized by an excess of soil water, at least for a short period of time. They are generally coarse textured with high acidity except in few patches with calcareous relies. Organic matter and nitrogen contents vary from low to moderately high depending on the intensity of water level and duration of water logging which influence the rate of organic matter degradation. The soils are generally low in exchangeable bases particularly potassium and magnesium.

Raphia palms farmers will encounter difficulties in managing low fertility soils, especially where there are no baseline data on inherent physical and chemical properties of the soils and the limits of nutrient requirements of raphia palm. Increased production will not only require additional inputs of N, P, K and Mg but also micronutrients to sustain high yields. At present there is little information on the fertilizer requirements for raphia palm in Nigeria. The available information is based on extrapolations from nursery fertility trials. Attempts at developing effective management of the soils supporting raphia palm, requires the use soil test data because it is essential to the determination of the potentials and constraints of soil to crop yield.

Since little seems to have been directed to identifying fundamental constraints of soils grown to *Raphia hookeri* in Onuebum in Bayelsa State. This present study aims at evaluating the soil properties of the area, identify constraints militating against the growth, development and yield of *Raphia hookeri* and to suggest appropriate correction measures to increase growth, development and yield of the palm.

MATERIALS AND METHODS

Description of study area:

The study was conducted at NIFOR Raphia palm substation at Onuebum in Bayelsa State. A total of 89 surfaces (0-15cm) and sub surface (15-30cm) soil samples were collected from 40 profiles in three selected locations in the *Raphia hookeri* Plantation. The locations covered the humid and sub-humid with mean annual rainfall of 3000 to 4000mm. This was randomly selected to represent the total hectares of the area. The selected location had no previous history of fertilization. The vegetation is dense tropical rain forest consisting mainly of freshwater swamps and raphia palms. Samples collected were bulked together in black polythene bags and were transported to the Agronomy analytical laboratory at the Main Station (NIFOR). The bulked soil samples were air dried and crushed to pass through a 2mm sieve prior to analysis.

Determination of soil physical and chemical properties:

Soil pH was determined in 1:1 soil, water suspension ratio and read in glass electrode pH meter. Mechanical analysis was done by the hydrometer method (Bouyoucous, 1951). Organic carbon was determined by the dichromate wet oxidation method (Walkley and Black, 1934) as modified by Jackson (1969). Total nitrogen was assessed by the micro-kjeldahl digestion method (Bremner, 1965). Available phosphorus was by Bray P-I- method (Bray and Kurtz, 1945). Exchangeable K, Ca, Na, and Mg were extracted with neutral 1 M ammonium acetate, K and Na in the extracts were determined with a Flame Photometer, while Ca and Mg were determined with an Atomic Absorption Spectrophotometer. Fe, Mn, Zn and Cu were extracted in 0.1 N HCL and then determined in an Atomic Absorption Spectrophotometer. Exchangeable acidity was determined using the method of Mclean (1965). The ECEC was by summation of exchangeable cations plus exchangeable acidity. The percent base saturation was calculated as the sum of exchangeable cations divide by the ECEC and multiplied by 100

RESULTS AND DISCUSSION

The result of physical properties of the hydromorphic soils supporting *Raphia hookeri* is presented in Table 1. The soil texture is dominated by the sand fraction which accounted for an average of 76.5% This reflects the dominance of quartz in the soils parent materials. The soils were generally coarse texture having high sand but low silt and clay contents. The silt /clay + silt) ratios were low, being less than unity in all the samples indicating most of the silt as having been weathered into clay. According to Stewart *et al.*, (1970), low silt and low silt/(clay + silt) ratios is an indicators of advanced weathering which arises from prolonged action or strong intensity of the weathering agents such as rainfall etc.

Table 1: Particle size distribution and textural classes of hydromorphic soils supporting *Raphia hookeri* at Onuebum NIFOR Sub-station.

Location		Soil depth (cm)	Sand %	Silt %	Clay %	Texture
Location	1	0 – 15	88.9-91.2	5.9-7.2	4.9-5.2	Sand Loam
		15 – 30	75.1-88.6	10.7-20.2	4.2-8.7	Loam Sand
Location	2	0 -15	85.1-89.1	7.7-10.7	1.7-8.2	Sand
		15-30	83.6-90.6	0.7-10.7	2.2-6.7	Sandy Loam
Location	3	0-15	36.1-87.6	4.9-5.6	4.9-5.2	Sand loam
		15-80	80.5- 90.5	6.5-8.0	4.2 – 8.7	Sand

Table 2: showed the chemical properties of soils supporting *Raphia hookeri*. The result of the chemical analysis showed that the soils were moderately to strongly acidic, having a pH value ranging from 4.30 to

4.71 with a mean of 4.50 for surface and 4.26 – 4.77 with a mean of 4.52 for sub-surfaces soil. This is rated as strongly acid (Holland *et al.,* 1989). According to Jacquemard *et al.,* (1998), oil palm can cope with acid soils with a pH as low as 4 or 45.

Raphia palm like oil palm can tolerate acid soils. The organic carbon contents of the soils were low ranging from 0.22 – 1.256gkg^{-1} with a mean value of 0.650gkg^{-1} for surface soils and 0.032 – 0.960 gkg^{-1} with a mean value of 0.502gkg^{-1} for sub-surface soils. The soil total N was generally low in the three locations. These ranging from 0.067 – 0.245 with a mean value of 0.096 gkg^{-1} for surface soils and 0.025 – 0.522 gkg-^{1} with a mean value of 0.076 gkg^{-1} for sub surfaces soils. The low total N values could be attributed to ineffective microbial degradation of organic matter in the waterlogged soils and also due to long period of flooding which usually last for 6 – 8 months in a year with few months of dryness.

There is a high variation in the degree of decomposition of the soils organic matter. And this is a reflection of the organic carbon content in the soils (Onyekwere *et al.,* 2003). Raphia palm are heavy feeder of N thus low content of N will likely have adverse effect on growth, development and yield. Thus external application of N in form of organic or inorganic fertilizer is required to enhance the growth, development and yield of the palms.

The available P was generally low except in location two where the values were moderately high. The mean values at this location ranged from 17.80 mgkg^{-1} for surface soils to 13.85 mgkg^{-1} for sub surface soils. Locations 1 and 2 have available P values less than 10 gkg^{-1} suitable for optimal productivity (FAO, 1976). *Raphia hookeri* is not a heavy feeder of phosphorus; hence the P content in these soils is not likely to limit the growth, development and yield of the palm. The exchangeable calcium, magnesium, potassium and sodium were very low.

The calcium contents were very low and less than 4.0 cmol kg^{-1}. According to Bohn *et al.,* (1979), high calcium content is very good for crop production, because it is an indication of low concentration of other potentially troublesome exchangeable cations like sodium and aluminum in acid soils. Exchangeable K and Mg were low. The lower contents of these basic cations may be caused by a high degree of leaching which is certainly aggravated by the high rainfall, sandy texture and the low pH of the soils.

Exchangeable sodium content was moderate. The value ranged from 0.611 – 1.522 cmol kg^{-1} with a mean value of 0.622 cmol kg^{-1} for surface soils to 0.585 – 1.522 cmol kg^{-1} with a mean value of 0.768 cmol kg^{-1} for sub-surface soil. The exchangeable acidity ranged from 1.05 – 2.04 cmol with a mean value of 1.55 cmol kg^{-1} for surface soils and 1.05 – 1.56 cmol kg^{-1} with a mean value 125 cmol kg^{-1} for sub-surface soils. The highest value was recorded at location 1 with the least value recorded at location 3. The effective cation exchange capacity (ECEC) was generally low, the values ranges from 3.331 – 8.012 cmol kg^{-1} with mean value of 4.757 cmol kg^{-1} for surface soils and 3.284 – 10.515 cmol kg^{-1} with a mean value of 6.416 cmol kg^{-1} for sub-surface soils.

According to FAO (1976), soils having ECEC value above 20 cmol kg^{-1} are regarded as being suitable for crop production, if other factors are favourable. The percentage base saturation values were moderate to high with all the values above 35% which is regarded as the critical level for the growth, development and yield of palm (Ibanga and Udo, 1996).

However, because water logging brings about increase in pH with attendant decrease in exchange acidity; the soils generally have high percentage base proportion of the reserves in exchangeable or extractable available forms. This could be the reason for high percent base saturation as observed. Thus these soils could support any plant that tolerates permanent or periodic wetness like *Raphia hookeri* palms. Generally it was observed that the soil at Onuebum where *Raphia hookeri* is cultivated had low CEC and this is an indication of a low buffering capacity. Also the soil were inherently low in total N, available P, thus for

optimal productivity of the palms, external inputs such as application of NPK and Mg fertilizers in form of organic or inorganic fertilizer is required to sustain growth and productivity.

RECOMMENDATION AND CONCLUSION:
Soil management can be defined as preparation and treatment of soils for the production of all types of agricultural economic plants (Aduayi and Ekong, 1981). A good system must ensure that the nutrient status of the soil is maintained, that all factors directly harmful to plant growth such as high acidity or alkalinity, poor drainage are absent. Management of Onuebum hydromorphic soils supporting *Raphia hookeri* for sustainable *Raphia hookeri* production can be achieved through the following ways.

(1) Use of soil conditioner
The area should be periodically lime with calcite or calcium carbonate; this will improve the soil structures. Soil conditioners such as lime or calcite (C_aC_o3) have been successfully used to improve the structure of acidic soils. Liming of soil increase the soil pH to near neutral and make P, exchangeable calcium and magnesium more available in the soil.

(2) Drainage
Onuebum soils usually is flooded 6-8 months in a year, thus for effective utilization of this land for meaningful productivity, excess water should be removed through good drainage system or channels. The objective of soil drainage is to control excess water so as to make the soil more stable for optimum plant growth. The excess water on the surface of the soil can be drained either by open drains or sub-surface methods such as the use of tile; mole drains perforated pipes as well as swap and pump approaches. Apart from leaching excess salts from the soil, drainage ventilates the soil, moderates soil temperature and makes soil moisture available to the rooting cane. Other benefit is that drainage elongate crop growing season and makes early planning and planting easy.

(2) Agronomic practices
The Agronomic practices of pudding (planning and harrowing), use of minimum tillage tools and implement to ensure good soil tilt, levelling of the land and construction of leaves to impound water and making of high mounds, ridges or beds enable us to put hydromorphic soils into productive use. The objective here is to lower the water table whereas the top soil is maintained at field capacity moisture level. Others agronomic practices include application of organic or inorganic fertilizers especially N and K fertilizer to boast soil fertility.

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Table 2: Chemical properties of soil supporting *R. hookeri*

		SOIL DEPTH (CM)				
Soil properties	Location 1		2		3 3	
	4.45	4.60	4.53	4.40	4.41	4.42
pH (H_20	4.41 – 4.71	4.42 – 4.77	4.46 – 4.62	4.26 – 4.67	4.30 – 4.51	4.27 – 4.47
	0.650	0.292	0.493	0.502	0.149	0.168
Org C ($gkg^{-}1$)	0.064 – 1.256	0.032 – 0.516	0.160 – 0.833	0.064 – 0.960	0.022 – 0.288	0.061 – 0.288
	0.096	0.310	0.104	0.076	0.153	0.120
Total N ($gkg^{-}1$)	0.073 – 0.125	0.087 – 0.522	0.067 – 0.142	0.05 – 0.136	0.071- 0.245	0.071 – 0.184
	10.53	10.91	17.80	19.62	13.85	12.46
Avail P. (mg kh^{-1})	6.405 – 14.663	7.973 – 13.838	16.874 – 19.018	15.465 – 23.711	4.827 – 20.783	6.932 -18.128
Exchangeable cation						
	1.78	3.04	1.93	2.60	1.45	1.78
Ca. (cmol $kg^{-}1$)	1.04 – 2.16	0.88 – 5 .60	1.52 – 2.40	1.44 – 4.16	1.20 – 2.00	1.20 – 2.64
	0.81	1.07	1.01	1.24	1.16	0.85
Mg (cmol $kg^{-}1$)	0.40 – 1.42	0.04 – 2.30	0.48 – 1.92	1.36 – 1.48	0.24 – 2.48	6.16 – 1.44
	0.240	0.170	0.242	0.251	0.268	0.247
K (cmol $kg^{-}1$)	0.127 – 0.353	0.103 – 0.273	0.174 – 0.310	0.113 – 0.44	0.113 – 0.413	0.247 – 599
	0.787	0.696	6.622	1.055	0.739	0.769
Na (mol $kg^{-}1$)	0.784 – 0.860	0.611 – 0.782	0.671 – 1.522	0.585 – 1.522	0.645 – 0.834	0.662 – 0.877
	1.86	1.40	1.75	1.20	1.14	1.14
EA (cmol $kg^{-}1$)	1.05 – 2.04	1.05 – 1.56	1.65 – 2.86	1.05 - 1.30	1.24 – 1.76	1.04 – 1.30
	5.477	6.416	5.554	6.346	4.757	4.787
EEC (cmol $kg^{-}1$)	3.331 – 6.833	3.284 – 10.515	4.495 – 8.012	4.548 – 8.876	3.438 – 7.497	3.309-4786
	66.0	77.6	68.5	81.1	76.0	76.2
B (%)	68.8 – 70.1	68.0 – 85.2	63.3 – 76.7	76.9 – 85.4	63.9 – 76.5	68.6 – 80.5