Response of Raphia (*Raphia Hookeri*) Palm Seedlings to Fertilizer Application

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Abstract

The effect of four rates of NPKMg fertilizer on the growth parameters of raphia palm (*Raphia hookeri*) was studied in the nursery for a period of 12 months. The four rates of fertilizer used per raphia seedling were 0; 14g; 28g; and 42g NPKMg and they were laid out in the field as Randomized Complete Block Design in four replicates. Results obtained showed that the use of fertilizers in raphia seedling production was of immense benefit to the palm as it significantly enhanced the vigorous and healthy growth of the palm as shown by macronutrient uptake and other growth parameters in fertilized plots.

Key words: *Nursery, fertilizer application, Raphia hookeri seedling, dry matter yield.*

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1. INTRODUCTION

Declining yields as a result of poor soil nutrient is becoming a threat to food and livelihood security across the country. The major challenge therefore is to reverse the tide of poor inherent soil fertility and increase the soil stocks through soil fertility management. Usman (2008) reported that poor soil fertility in small holder farms is the fundamental root causes of declining per capital food production in Africa. They further advocates that soil fertility replenishment should be considered as an investment. Usman (2008) also pointed it out in the work that no matter how effectively other conditions are met per capita food production in Nigeria will continue to decline unless soil fertility is effectively addressed. He further stated that achieving balance between the nutrient requirements of plants and the nutrient reserves in the soils is essential for maintaining high yields and sustaining agricultural production over a long term.

A very crucial aspect of improving and maintaining soil fertility according earlier literature for instance Omoti (1989) is the application of nutrients to soils deficient in such nutrients. Adequate nutrient is an important factor for high yields of field crops. Nitrogen (N), Phosphorus (P), Potassium (K) and Magnesium (Mg) are the most important plant nutrients in palm cultivation both in the nursery and on the field. The hydromorphic soils supporting *Raphia hookeri* have low inherent soil nutrients and apart from poor drainage, the CEC is very low. Nitrogen (N), Phosphorus (P) and Potassium (K) deficiencies are the major limiting factor in these soils. *Raphia hookeri* requires these elements for growth, development and yield. Inadequate supply of these elements according to Ndon (2003) will results in poor growth development and yield which will adversely affect its cultivation. According to Ojeniyi (2000), application of inorganic fertilizer has been found to improve crops yield and soil chemical properties such as soil pH, total nutrient content and nutrient availability.

A good fertilizer management programme is important to achieve good soil nutrient status that will sustain *Raphia hookeri* growth and development thereby leading to high palm yields. *R. hookeri* must receive adequate nutrients in balanced proportion to ensure healthy vegetative growth, development and good crop yields. Fertilizer must be applied in prescribed manner over the area of the plantation that will result in most efficient uptake by the palm. The plantation industry is a business venture and therefore the economic value of fertilizer input is important. The increase in yields upon usage of fertilizers will reduce the cost of production and fixed cost enabling continued profitability.

Currently several farmers have shown interest in the cultivation of *Raphia hookeri* but their effort is limited by inadequate information on the current nutrient status of soil supporting the crop. With the present agricultural policy by Nigeria government to diversify the economy from sole dependence on petroleum to agriculture in order to alleviate poverty and economic empowerment of her citizen, more people are attracted to agriculture. Increased *R. hookeri* production will not only require additional inputs such as N, P, K and Mg, but also micro - nutrients to sustain high yielding since little seems to have been done in *R. hookeri* agronomic practices. Thus, this study investigates the response of *Raphia hookeri* seedling to various rates of NPKMg 12:12:17:2 fertilizer with the view to determine the optimum fertilizer rate needed for successful nursery seedling production of raphia palm.

2. MATERIALS AND METHODS

Study location:

The experiment was conducted at the Nigerian Institute for Oil palm research (NIFOR), Main station, Benin City, Edo State, Nigeria. It lies within Latitudes 6^o 33’ and 7^o 25’ North of the Equator and Longitudes 5^o 15’ and 5^o 37’ East of the Greenwich Meridien. The site was cleared, parked, stumped and levelled. NIFOR soils has been classified by various scientists as acidic, sandy with low silt, well drained, low to moderate fertility and it is commonly called Benin fasc (Aghimen, 1982 and Ogunkunle, 1983). The nutrient status of the nursery site was determined before the experiment was laid out using standard soil analytical procedures. Soil samples were collected using soil auger at a depth of 0 – 15 cm. The soil samples collected were compounded, air dried, and sieved with the 2mm sieve after which the physical and chemical properties were determined. Particle size distribution analysis was by the use of hydrometer method (Bouyoucos, 1951), while the soil pH was determined using a glass electrode pH meter at a ratio 1:1 soil to water suspension (Mclean, 1982). The organic carbon content was determined by dichromate wet oxidation method of Walkley and Black (1934). The total available soil nitrogen was determined using macro Kjeldahl method as described by (Jackson, 1969) available P by Bray 1 method (Bray and Kurtz, 1945), exchangeable bases (Exch. Ca, Mg, K and Na) was extracted using 5g of the soil. 5g from the soil samples was leached with 50ml of ammonium acetate at pH7. Flame photometer was used to determine K and Na, while the Ca and Mg were determined with Atomic Absorption spectrometer (AAS).

Treatments and experimental layout:

There were a total of four treatments which were the four rates of fertilizer used – (0, 14, 28, and 42g NPKMg) per seedling. These were laid out in the field as Randomized Complete Block Design in four replicates. The experimental site measured 27 m x 8 m (216 sq m). Each treatment was replicated four times to give a total of 16 treatment plots and each plot contained nine seedlings. Black polythene bags each measuring 40 cm x 35 cm (500 gauges) were filled with the nursery top soil up to 2 cm from the brim. The filled bags were allowed to consolidate for at least two to three weeks; thereafter the filled bags were arranged at a spacing of 45 cm x 45 cm. The average weight of a polybag filled with top nursery soil was 17.0 kg. The planting materials were obtained from the Plant Breeding Division, NIFOR. The collected *Raphia hookeri* seeds were pre-germinated using Otedoh, (1977b) method. All the sprouted ones were later sown into the polythene bags for the fertilizer experiment at a depth of 3.0 cm as described by Iremiren and Onwubuya (1985). The polybags were watered as at when due and also regular weeding was carried out to make the experiment weed free.

Fertilizer application:

Fertilizer application was done at 3 months after planting as a single dose per treatment and the method of fertilizer application was by placing at 5.0 cm below the soil in the polybag.

Agronomic data collected:

The survival and transplantable seedlings was done on physical observation based on the number of healthy and vigorous seedlings (no serious damage by pests and disease, absence of morphological irregularities and retarded growth) that had reached a height of at least 70 cm, and at least 11 leaves and a girth of 13 cm and above with no growth abnormalities (Ugbah, 2008). The seedling physical growth, development and dry matter parameters were collected at 3, 6, 9 and 12 months after planting. Data collected were palm height, palm girth, number of palm frond production, leaf area, percentage transplantable seedlings, incidence of pests and diseases, fresh and dry matter yield, nutrient uptake, leaf nutrient composition and fertilizer use efficiency. The palm height was measured with the aid of a metre rule from the base of the palm to the top of the drawn up levels. Palm base circumference (girth) or the stem diameter was measured with a thread at the palm base and measured on metric rule. The number of palm frond was measured by physical counting of the healthy fronds except the spear. The leaf area was estimated by the methods described by Hardon *et al* (1969) and Corley *et al* (1976) obtained eleven months after planting. The experiment was terminated at 12 months after planting.

Yield data collected:

Fresh and dry matter yield was obtained eleven months after planting, while the experiment was terminated at 12 months after planting. The stem, leaves and root were oven dried at 85 ^{o}C for 48 to 72 hours, weighed to obtained dry matter yield. The oven dried stem, leaves and roots were milled and analysed for N, P, K, Ca, Mg and Na contents. Two gram of a milled sample was re-dried at 105 ^{o}C for two hours and ashed at 550 ^{o}C for three hours in a muffle furnace. The ash was digested in a hot water bath for 30 minutes with 25 ml of 20 % HNO_3 filtered and made up to 250 ml distilled water. Extract from these were used for the determination of phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg) and Sodium (Na). While one gram of dried sample was digested and made up to 100 ml to estimate total Nitrogen (N) using micro kjedhal method. K, Ca, and Na were determined using flame photometry, while Mg was determined colourimetrically by the titan yellow method. N and P were determined on a Technicon auto –analyzer (AA2) using indophenol blue and molybdenum blue method respectively. Total nutrients uptakes were computed as the percentage concentrations of N, P, K, Mg and Na in plants multiply by plants dry weight.

Statistical analysis

Data collected were subjected to analysis of variance (ANOVA) and tests of significance of treatments were carried out using Duncan's New Multiple Range Test (DNMRT) at 5% level of probability.

3. RESULTS

Physical and chemical status of experimental sites

The results of the physical and chemical properties of the soil used for the nursery seedling experiment before planting are as shown in Table 1. Results showed that the nursery experimental soil texture was loamy sand. The soil pH was moderately acidic at 5.6. NIFOR soils are described as acidic, sandy with low silt, well drained, low moderate fertility and are commonly called Benin Fasc (Ogunkunle, 1983). The soil total nitrogen was generally poor having a mean value of 1.25 g kg^{-1}which is less than the soil critical level of 3 g kg^{-1} established. Nitrogen is an important element in Raphia seedling nutrition and for optimum seedlings production N must be in adequate supply.

Effect of NPKMg fertilizer on *Raphia hookeri* seedling height, girth, number of green leaf and leaf area

Raphia hookeri seedlings height as influenced by applied rates of NPKMg fertilizer at 3, 6, 9 and 12 months after planting is presented in Table 2. The rates of NPKMg 12:12:17:2 significantly ($P \leq 0.05$) enhanced seedlings growth at 9 and 12 months after planting. The rates of fertilizer had no significant effects on seedlings height at 3 months after planting. However, after 3 months of planting there were pockets of significant differences at 6 months but this become more pronounced at 9 and 12 months after planting. *Raphia hookeri* seedling girth (cm) as influenced by applied rates of NPKMg fertilizers are presented in Table 3. The results followed a similar pattern as in Table 2, where the applied fertilizer had significant ($P \leq 0.05$) effects on palm height. The significant effect of rates of applied fertilizers on stem girth is an indication of enhanced soil nutrients resulting from the applied fertilizers. Highest seedling girth was obtained (13.44cm) when fertilizers were applied at 28g / seedling while the least (12.16 cm) was obtained at the control.

Applied fertilizer application had significant effects on palm frond production at 9 and 12 month after planting Table 4. The significant effects of fertilizer at 9 and 12 after planting are an indication that the palms need addition of external inputs for optimum production. As fertilizer rates increased the numbers of leaves produced were significantly increased compared to fertilizer rate at zero (control).

The response of *Raphia hookeri* seedling to applied rates of NPKMg fertilizer on seedling leaf area is presented in Table 5. Applied rates of NPKMg fertilizers significantly ($P \leq 0.05$) influence seedling leaf area. Highest leaf area (72.59 cm^3) was obtained when 42g NPKMg fertilizer per seedlings was applied at 12 months after planting. However, this was not significantly different from seedlings treated with 14 and 28g NPKMg / seedling respectively. All seedlings treated with NPKMg 12:12:17:2 exhibited significant difference from all control seedlings in term of leaf area production.

Table 1: The physical and chemical properties of the soil before planting

Soil Properties	**Values**
Sand (g kg^{-1})	862
Silt (g kg^{-1})	20
Clay (g kg^{-1})	118
Texture Class	LS
Bulk density (g/cm^{-3})	13.8
pH	5.6
Organic Matter ((g kg^{-1})	16.1
Total Nitrogen (g kg^{-1})	1.25
Available P (ppm)	36.16
Exchangeable cations	
Magnesium (Mg) cmol (+) kg^{-1}	1.60
Calcium (Ca) cmol (+) kg^{-1}	4.80
Potassium (K) cmol (+) kg^{-1}	0.231
Sodium (Na) cmol (+) kg^{-1}	0.052

LS: Loamy sand

Table 2: Effect of fertilizer application on *Raphia hookeri* seedlings height (cm) at 3, 6, 9 and 12 months after planting

Fertilizer rates	Months	After	Planting	
(g /seedling)	3	6	9	12
0	13.50a	26.10b	67.43c	92.56c
14	13.38a	26.59b	75.70b	94.29b
28	13.38a	28.08a	81.14a	103.54a
42	13.09a	28.67a	82.68a	97.62ab
Mean	13.34	27.36	76.74	97.00

Mean with the same alphabets in the same column are not significantly different from each other by Duncan's New Multiple Range Tests (DNMRT) at 5% level of probability

Table 3: Effect of fertilizer application on *Raphia hookeri* seedlings girth (cm) at 3, 6, 9 and 12 months after planting

Fertilizer rates	Months	After	Planting	
(g/ seedling)	3	6	9	12
0	3.822a	6.044c	8.398c	12.16c
14	3.589ab	6.333bc	8.856b	13.09c
28	3.678ab	6.533b	9.764a	13.44a
42	3.500b	6.867a	9.878a	12.62b
Mean	3.647	6.444	9.224	13.08

Mean with the same alphabets in the same column are not significantly different from each other by Duncan's New Multiple Range Tests (DNMRT) at 5% level of probability

Table 4: Effect of fertilizer application on *Raphia hookeri* seedlings number of leaf production (leaf number) at 3, 6, 9 and 12 months after planting

Fertilizer rates (g/seedling)	Months	After	Planting	
	3	6	9	12
0	3.723ab	5.722b	7.667b	10.553a
14	3.927a	5.789b	7.711b	10.544a
28	3.483b	6.022a	8.033a	10.878a
42	3.400b	6.00a	7.733b	10.711a
Mean	3.632	5.883	7.786	10.667

Mean with the same alphabets in the same column are not significantly different from each other by Duncan's New Multiple Range Tests (DNMRT) at 5% level of probability

Table 5: Effect of fertilizer application on *Raphia hookeri* leaf area (cm^3) at 3, 6, 9 and 12 months after planting

Fertilizer rates (g/seedling)	Months	After	Planting	
	3	6	9	12
0	0.2300a	19.64c	45.58c	58.83b
14	0.2133a	21.03bc	48.59bc	67.96a
28	0.2200a	23.09b	55.17a	67.94a
42	0.1944b	27.52a	52.44ab	72.59a
Mean	0.2144	22.82	50.47	66.83

Mean with the same alphabets in the same column are not significantly different from each other by Duncan's New Multiple Range Tests (DNMRT) at 5% level of probability

Effect of applied NPKMg on *R. hookeri* seedling macro nutrient distribution, dry matter yield and seedling percentage transplantable

The effect of applied NPKMg fertilizer on macro nutrient distribution on *Raphia hookeri* seedling is presented in Table 6. The result of the chemical analysis for macro nutrient distribution indicates the significant ($P \leq 0.05$) influence of applied fertilizer on macro nutrient distribution on *Raphia hookeri* seedlings 12 months after planting. The applied fertilizers had effects on soil nutrient availability which in turn enhanced nutrient uptake by *R. hookeri* seedlings as shown in the plant tissues nutrient composition. Applied NPKMg fertilizers at various levels increased the nutrient uptake or distribution in *Raphia hookeri* seedlings and this were significantly higher than the control. N, K and Mg uptakes in the plants increase as fertilizer rates increases. Highest amount of N (2.65) was obtained when fertilizer was applied at 42 g / seedling while the least N (0.81) was obtained at 0 g / seedling. Effect of applied NPKMg Fertilizer on mean fresh, mean dry matter yield and mean percentage transplantable is presented in Table 7. Fertilizer application had marked significant ($P \leq 0.05$) effects on all parameters measured. Fresh weight increased from 134.6 g / seedling (21.4 %) to 152.3 g / seedling to 175.1g/seedling (27.9%) when 28g of fertilizer was applied. The dry matter yield increased from 117.6 g/seedling (22.9 %) to 134.9 (26.3%). While seedlings transplantable percentage also increased from 56.4% to 74.9%. Least dry matter yield and percentage transplantable were obtained when no fertilizers were used.

Table 6: Effect of NPKMg 12-12-17-2 fertilizer on the distribution of major nutrients in *Raphia hookeri* seedlings (Nutrients expressed as percentage of dry matter)

Treatment	Macro Nutrient				
NPKMg g/seedling	N	P	K	Mg	Ca
0	0.81c	0.08c	0.06b	0.09b	0.30c
14	1.50b	0.19b	0.84a	0.20a	0.36b
28	2.05ab	0.24a	0.86a	0.24a	0.41a
42	2.65a	0.26a	0.86a	0.23a	0.37ab
Mean	1.75	0.19	0.67	0.19	0.37

Mean with the same alphabets in the same column are not significantly different from each other by Duncan’s New Multiple Range Tests (DNMRT) at 5% level of probability

Table 7: Effect of varied rate of applied NPKMg 12:12:17:2: on *Raphia hookeri* seedling dry matter yield and transplantable seedlings 12 months after planting.

Treatments NPKMg (g/seedlings)	Fresh weight (g/seedling)	Dry weight (g/seedling)	Transplantable seedlings (%)
0	134.6c	117.6b	56.44c
14	152.3b	125.1ab	60.89b
28	175.1a	134.9a	74.11a
42	166.1a	134.1a	74.89a
Mean	157.0	127.9	66.58

Mean with the same alphabets in the same column are not significantly different from each other by Duncan's New Multiple Range Tests (DNMRT) at 5% level of probability

The physical and chemical properties of the soil after crop harvest.

The soil physical and chemical properties after planting for the nursery seedling experiment result are presented in Table 8. Results showed that the nursery experimental soil texture is loamy sand. Sand fraction was 852 g kg^{-1} while the silt and clay values were 25 g kg^{-1} and 119 g kg^{-1}) respectively. The soil pH is dropped to 5.4. The soil total nitrogen increased from 1.25 g kg^{-1} at pre planting to 1.59 gkg^{-1} post planting. The soil macro nutrients were moderate when compared to initial soil physical and chemical properties.

Table 8: The physical and chemical properties of the soil after crop harvest

Soil Properties	Values (post)
Sand (g kg^{-1})	856
Silt (g kg^{-1})	25
Clay (g kg^{-1})	119
Texture Class	LS
Bulk density (g/cm^{-3})	1.28
pH	5.4
Organic Matter ((g kg^{-1})	14.5
Total Nitrogen (g kg^{-1})	1.59
Available P (mg kg^{-1})	38.6
Magnesium (Mg) cmol (+) kg^{-1}	1.25
Calcium (Ca) cmol (+) kg^{-1}	0.98
Potassium (K) cmol (+) kg^{-1}	0.108
Sodium (Na) cmol (+) kg^{-1}	0.116

LS: Loamy sand

4. DISCUSSION

Soil physical and chemical properties

Results of the soil pre and post analyses showed that the nursery experimental soil texture is loamy sand. The soil pH was moderately acidic and the sand fraction dominate the soil texture with low silt, free draining, low moderate fertility and are commonly called Benin Fasc (Vine, 1956, Agboola, 1979 and Ogunkunle, 1983). The soil total nitrogen was generally poor and nitrogen is an important element in *Raphia* seedling nutrition and for optimum seedlings production N must be in adequate supply. The soil macro nutrients were generally low and this finding was in agreement with early finding of Aghimien *et al* (1985) who reported that the soils are derived from alluvial of riverine and marine characterized with low silt, clay, nutrient and high acidity. Thus for optimum seedlings production the nursery soils needs application of fertilizers to improve the soil nutrients.

Raphia growth and yield parameters

The statistical analysis of growth and yield response of *Raphia hookeri* seedling to applied varied rates of NPKMg fertilizer at 3, 6, 9 and 12 months after planting showed that NPKMg fertilizer enhanced seedlings growth and yield at 9 and 12 months after planting. Application of fertilizer at 3 months after planting had no significant effects on seedling palm height, girth, leaf number production and leaf area. The non significant effects of fertilizer 3 months after planting may be attributed to the fact that the *R. hookeri* seeds may have stored up food in its endosperm that can sustain the seedlings in the first few weeks of it growth.

According to Otedoh (1977b), *R. hookeri* store up food in its seeds which is used for growth at its early stages of development until it has 3 to 4 leaves, which will then carry out photosynthesis. This finding was in agreement with Iremiren (1982) in his study on the suitability of using black polythene bags for raising raphia seedling. However, after 3 months of planting there were pockets of significant differences at 6 months but this become more pronounced at 9 and 12 months after planting. This is an agreement with Iremiren and Onwubuya (1985) who reported that the food reserved in the endosperm of *R. hookeri* seed is not sufficient to meet the nutritional requirements of the *R. hookeri* seedling. This difference observed among the seedling height, girth, leaf number and leaf area could be attributed to applied fertilizers.

The applied fertilizers had effects on soil nutrient availability which in turn enhanced nutrient uptake by *R. hookeri* seedlings as shown in the plant tissues nutrient composition. Applied NPKMg fertilizers at various levels increased the nutrient uptake or distribution in *Raphia hookeri* seedlings and this were significantly higher than the control. N, K and Mg uptakes in the plants increase as fertilizer rates increases. Highest amount of N (2.65) was obtained when fertilizer was applied at 42 g / seedling while the least N (0.81) was obtained at 0 g / seedling. Applied fertilizer at lowest rate of 14 g /seedling increased N availability in *R. hookeri* seedling by 46 % over the control while at 42 g /

seedling N availability was 69.4 % over the control. At lowest rate of 14 g / seedling K availability increased by 92.8 % while P, Mg and Ca increased by 57.9, 55 and 16.7 % respectively. Iremiren and Onwubuya (1985) in their study of response of the oil palm to nitrogen fertilizers in a secondary forest reported that N, P, K, Mg and Ca distribution in leaf 17 were significantly influenced by applied N fertilizers. They further stated that the amount of these elements exceeded the critical levels established for oil palm. This, they attributed to adequate soil nutrients in the soils.

The result also is in agreement with Remison and Jose (1991). In their findings they reported that all palms fertilizers with NPKMg had higher N content than the control while the P content was not affected by the treatments. They further stated that K, Mg and Ca contents were affected by treatments but not as high as that of N content. It should be noted here that the level of nutrient concentration in the seedling is indicative of the extent of nutrient removal of this elements from the soil by the plant. While N and K were easily removed by the seedlings, levels of P, Mg and Ca were relatively low and may perhaps explain why they are not needed in large quantities in subsequent growth in the nursery as well as in the field. According to Aghimien *et al* (2011), at the nursery stage where nutrients are expected to be applied in adequate amount to enhance healthy and optimum growth at later stages, nutrient demand is in the order of N > K> Ca > P > Mg with N is in highest demand. The importance of N and K for nursery seedlings was significantly shown in this experiment

5. CONCLUSION

The results of the study showed that applied varied rates of NPKMg fertilizers significantly influenced *R. hookeri* seedlings macro nutrient uptake, concentration and development as palms treated with varied rates of NPKMg fertilizers were very vigorous, healthy and with greenish leaf colour compared to the control with pale yellow leaf colour. The vigorous and healthy growth of seedlings treated with NPKMg fertilizers over the control has confirmed that the chlorosis symptoms and poor growth among *R. hookeri* seedlings in the nursery are not hereditary but environmentally induced. Hence it is beneficial to fertilizer

Raphia seedling production for enhanced macro-nutrient uptake, healthy, greenish and vigorous raphia nursery seedlings.

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