ISSN 1819-1894

Asian Journal of Agricultural Research

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OPEN ACCESS Asian Journal of Agricultural Research

ISSN 1819-1894
DOI: 10.3923/ajar.2020.13.18

Research Article
Coconut (*Cocos nucifera* L.) Seedlings Performance in Relation to Rock Phosphate Application in an Ultisol at Nifor Main Station

[1]Osayande Pullen Efosa, [1]O. Oviasogie Philip and [2]O. Orobator Paul

[1]Soils and Land Management Division, Nigerian Institute for Oil Palm Research, P.M.B. 1030, Benin City, Nigeria
[2]Department of Geography and Regional Planning, University of Benin, Benin City, Nigeria

Abstract
Background and Objective: Coconut is fondly called the tree of life and recent studies have indicated that the seedlings can be improved by addition of inputs. Therefore, main objective of the study was to find the relation between the coconut seedling and rock phosphate. **Materials and Methods:** Rock phosphate as a source of phosphorus fertilizer for coconut (*Cocos nucifera* L.) seedlings was evaluated for twelve months (June, 2013-June, 2014) at NIFOR Main Station. The study conducted in two tasks was laid out in a completely randomized design (CRD) and consisted of 4 levels of rock phosphate namely 0, 100, 200 and 300 g in 5 replications. Data were collected on plant height, stem girth, leaf area and number of leaves at 4, 8 and 12 MAPs (months after planting). **Results:** Results showed that application of rock phosphate with a basal application of NPK 15:15:15 gave better performance than application of rock phosphate with a basal application of urea throughout the study period. **Conclusion:** The study concludes that rock phosphate can be used to raise healthy and transplantable coconut seedlings in a naturally leached sandy soil with minimal use of NPK fertilizer in a cost effective way.

Key words: Transplantable coconut, NIFOR, NPK, rock phosphate, soil, urea

Citation: Osayande Pullen Efosa, O. Oviasogie Philip and O. Orobator Paul, 2020. Coconut (*Cocos nucifera* L.) seedlings performance in relation to rock phosphate application in an Ultisol at NIFOR main station. Asian J. Agric. Res., 14: 13-18.

Corresponding Author: Osayande Pullen Efosa, Soils and Land Management Division, Nigerian Institute for Oil Palm Research, P.M.B. 1030, Benin City, Nigeria

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Coconut (*Cocos nucifera* L.) is an economic palm that is widely cultivated in the Southern part of Nigeria, especially in areas dominated by coastal alluvium soils. It is currently known that the demand for coconut and its products currently outweighs its production in Nigeria. This short fall in the production of coconut in Nigeria can only be bridged through the addition of fertilizers to boost growth of the crop. According to Sobulo[1], use of fertilizer has been shown to increase yield by 200% when the right type and quantity are used. The reduction in fertilizer subsidy has affected the quantity of fertilizer application in most developing countries including Nigeria. Deregulation will further increase cost of production[1,2]. This situation has stimulated interest in the use of locally sourced fertilizer materials such as rock phosphate as well as the production and use of locally sourced materials like compost and biochar.

The discovery of large deposits rock phosphate in Sokoto put at between 5 and 10 million t and relatively high (32-34% P_2O_5) level of content has encouraged the research and development on the rock. The use of rock phosphate as a source of phosphorus for the oil palm has been reported by Isenmila *et al*.[3] and Oviasogie[4] in separate experiments. Uwumarongie-Ilori *et al*.[5] evaluated the potential of rock phosphate as a source of phosphorus for fertilizing the oil palm in a sorption study conducted at NIFOR. The findings of these experiments showed that rock phosphate can supply the phosphorus requirement of the oil palm and by extension coconut palms.

Of the coconut-growing countries in the world, Sri Lanka alone appears to have shown consistently and significant effects of P fertilizer on coconut parameters. Wahid *et al*.[6] showed significant effects of P fertilizer on nut and copra yield of coconut palms. Experiments carried out in different places in Sri Lanka as reported by Nethsinghe[7] and Balakrishnamurti[8] also showed spectacular yield responses to application of P. Later works by Loganathan *et al*.[9] confirmed phosphorus as an important essential major nutrient for both immature (non-bearing) and mature (bearing) coconut.

The objective of this study was to evaluate the effects of phosphorus on poly bag coconut seedlings at NIFOR main station.

MATERIALS AND METHODS

Description of study area: The experiment was carried out at the Soils and Land Management Division of the Nigerian Institute for Oil Palm Research located on Latitude 6°33[1] N and Longitude 5°37[1]E and 149.4 masl. Sprouted seed nuts of the hybrid variety of coconut were sown in late June of 2013.

Experimental design: The seedlings of identical heights were sorted out three months after sowing and treatments were randomly assigned using the completely randomized design (CRD) in 5 replications. The study was set up as two tasks; task 1 had a 45 g basal application of NPK 15:15:15 while task 2 had a 65 g basal application of Urea (N = 46%). The control palms also received a basal application of NPK 15:15:15 or Urea but no rock phosphate. Total experimental units were forty.

Data collection and analysis: Data collection started exactly 3 months after sowing of the sprouted seed nuts (one month after treatment application) in late September of 2013 and terminated in late June of 2014 (12 months after sowing and 10 months after treatment application). Data collected after 4, 8 and 12 months of treatment application are presented for discussion. These data were plant height, stem girth and number of leaves; these parameters were measured following[10]. Leaf area was measured using the regression model according to the method of Mathes *et al*.[11]:

$$y = 2.2138+0.7192x$$

where, x is the product of leaf length and breadth which were measured using a measuring tape. Data collected were subjected to analysis of variance (ANOVA) using Genstat statistical software while significant means were separated using Duncan's new multiple range test (DNMRT).

RESULTS

The soils used for this study were primarily fine and coarse sand. The results of the soil's chemical properties are shown in Table 1. The soils were acidic while the major nutrients such as

Table 1: Physical and chemical properties of the soil used for the experiment

Parameters	Values
pH (H_2O)	5.50
Organic carbon (%)	0.50
Total nitrogen (%)	0.08
Available phosphorus (mg kg^{-1})	5.50
Exchangeable K (cmol kg^{-1})	0.10
Ca (cmol kg^{-1})	2.50
Mg	0.20
Na	0.10

Table 2: Phosphorus composition (%) of milled Sokoto rock phosphate used for the study

1 M HCl	6 M HCl	Perchloric acid	Water soluble
28.62	25.16	36.98	1.24

Source: Oviasogie and Uzoekwe[15]

Table 3: Effect of rock phosphate and basal application of NPK 15:15:15 and urea on plant height (cm) of nursery coconut seedlings at NIFOR main station

Ground rock phosphate	Basal application of NPK 15:15:15 (MAP)			Basal application of urea (MAP)		
(g pot^{-1})	4	8	12	4	8	12
0	84.5^{a}	127.5	149.0	40.3	87.0	113.0
100	93.5^{ab}	126.8	152.9	34.4	66.0	97.0
200	99.0^{b}	133.3	156.2	31.4	89.8	131.0
300	90.9^{ab}	123.4	152.2	34.4	77.5	119.0

Duncan's new multiple range test (DNMRT), 4 MAP: 4 months after planting (2 months after treatment application), 8 MAP: 8 months after planting (4 months after treatment application), 12 MAP: 12 months after planting (8 months after treatment application)

Table 4: Effect of rock phosphate and basal application of NPK 15:15:15 and urea on stem girth (cm) of nursery coconut seedlings at NIFOR main station

Rock phosphate	Basal application of NPK 15:15:15 (MAP)			Basal application of urea (MAP)		
(g pot^{-1})	4	8	12	4	8	12
0	7.6^{a}	10.9	10.9	6.3	7.3	11.6
100	8.6^{b}	10.8	10.6	6.2	7.8	8.5
200	7.7^{a}	11.7	11.1	5.9	8.0	9.1
300	7.3^{a}	11.0	11.2	6.2	8.2	10.1

Duncan's new multiple range test (DNMRT), 4 MAP: 4 months after planting (2 months after treatment application), 8 MAP: 8 months after planting (4 months after treatment application), 12 MAP: 12 months after planting (8 months after treatment application)

total nitrogen, available phosphorus and exchangeable potassium were low. Calcium, magnesium and sodium were also low (Table 1). The phosphorus composition of the Sokoto rock phosphate used for the study is shown in (Table 2). Total phosphorus as determined by the use of perchloric acid was high (36.98%) while available phosphorus determined in a mineral acid and water were higher in acid extraction than water (Table 2).

Effects of applied rock phosphates with a basal application of NPK 15:15:15 and urea on plant height of poly bag nursery coconut seedlings at NIFOR main station: At 4 months after planting (MAP) and 2 months after treatment application, mean plant height was significantly improved with the application of 200 g rock phosphate and basal application of NPK 15:15:15 when compared with the control (Table 3). Application of 100 and 300 g of rock phosphate also gave higher values of plant height when compared with the control at 4 months after planting (MAP) and two months after treatment application. At 8 months after planting (MAP) and 6 months after treatment application, rock phosphate application had no significant effect on plant height though mean plant height was higher in coconut palms that received 200 g application (Table 3). Application of rock phosphate with a basal application of Urea did not significantly improve the mean plant height of coconut seedlings throughout the study. However, mean plant height was highest in palms that received 200 g rock phosphate with a basal application of urea at 8MAP (Months after planting and 6 months after treatment application) and 12 MAP, 10 months after treatment application when compared with the control (Table 3).

Effects of applied rock phosphate with a basal application of NPK 15:15:15 and urea on stem girth of poly bag nursery coconut seedlings at NIFOR main station: Application of 100 g rock phosphate with a basal application of NPK 15:15:15 significantly improved stem girth when compared with the control (Table 4) at 4 MAP (Months after planting and 2 months after treatment application). Application of 200 and 300 g of rock phosphate with a basal application of NPK 15:15:15 improved stem girth over control at 8 and 12 MAP. Application of rock phosphate with a basal application of Urea did not significantly improve mean stem girth throughout the period of study (Table 4).

Effects of applied rock phosphate with a basal application of NPK 15:15:15 and urea on leaf area of poly bag nursery coconut seedlings at NIFOR main station: At 8 MAP (8 months after planting and 6 months after treatment application), mean leaf area increased with increasing application of rock phosphate (Table 5). This trend continued at 12 MAP (twelve months after planting and 10 months after treatment application). Application of rock phosphate

Table 5: Effect of rock phosphate and basal application of NPK 15:15:15 and urea on leaf area (cm^2) of nursery coconut seedlings at NIFOR main station

Rock phosphate ($g\ pot^{-1}$)	Basal application of NPK 15:15:15 (MAP)			Basal application of urea (MAP)		
	4	8	12	4	8	12
0	641.2[a]	1199.0	1736.0	204.1	763.4	2655.0
100	729.9[a]	1372.0	1961.0	88.8	382.8	755.0
200	912.6[b]	1623.0	2079.0	131.1	669.2	1571.0
300	694.4[a]	3365.0	1846.0	173.3	564.1	1067.0

Means without alphabetical letters across columns are not statistically different using Duncan's new multiple range test (DNMRT), 4 MAP: 4 months after planting (2 months after treatment application), 8 MAP: 8 months after planting (4 months after treatment application), 12 MAP: 12 months after planting (8 months after treatment application

Table 6: Effect of rock phosphate and basal application of NPK 15:15:15 and urea on number of leaves of nursery coconut seedlings at NIFOR main station

Rock phosphate ($g\ pot^{-1}$)	Basal application of NPK 15:15:15 (MAP)			Basal application of urea (MAP)		
	4	8	12	4	8	12
0	4.4	6.4	6.2	3.0	4.8	5.5
100	4.6	6.0	5.8	3.4	4.6	5.4
200	4.8	6.4	6.4	2.6	5.0	6.0
300	4.2	6.4	6.6	2.6	4.3	5.5

4 MAP: 4 months after planting (2 months after treatment application), 8 MAP: 8 months after planting (4 months after treatment application), 12 MAP: 12 months after planting (8 months after treatment application)

Table 7: Rainfall (mm) obtained at NIFOR main station from 2005-2013

	Year								
Month	2005	2006	2007	2008	2009	2010	2011	2012	2013
January	0.0	22.5	0.0	0.0	1.6	0.0	0.0	65.4	22.9
February	15.7	10.5	104.2	0.0	134.9	57.5	116.2	34.4	31.9
March	167.2	61.1	56.2	95.3	78.3	38.7	84.9	45.4	45.4
April	114.4	158.0	197.7	98.3	226.6	219.9	118.3	162.4	221.3
May	138.9	246.8	246.2	137.1	248.6	125.4	264.0	188.8	199.3
June	292.7	172.5	380.9	256.6	207.7	174.6	275.2	265.2	190.5
July	406.8	289.0	284.7	276.6	148.7	257.8	430.3	396.9	240.1
August	80.9	335.9	171.4	313.9	254.0	455.8	277.8	139.9	69.3
September	177.3	347.4	256.0	371.7	278.1	282.1	250.9	317.5	469.6
October	167.2	304.5	285.0	68.6	192.8	373.8	240.8	178.9	153.5
November	33.9	24.7	37.1	6.9	109.4	109.0	68.8	46.9	70.7
December	0.0	0.0	17.1	23.6	1.3	0.0	0.0	0.0	13.0

Source: Statistics Division, Nigerian Institute for Oil Palm Research (NIFOR)

with a basal application of urea did not improve the leaf area of hybrid coconut seedlings over control (Table 5).

Effects of applied rock phosphate with a basal application of NPK 15:15:15 and urea on mean leaf number of poly bag nursery coconut seedlings at NIFOR main station: Application of rock phosphate and a basal dressing with urea or NPK 15:15:15 did not significantly improve mean leaf number of coconut seedlings (Table 6). Application of 100 g rock phosphate slightly increased mean number of leaves over control at 4 MAP and decreased mean number of leaves at 8 and 12 MAP (Table 6). Application of 100 g rock phosphate with a basal dressing with urea slightly increased mean coconut leaf number at 4 MAP while application of 200 g rock phosphate with a basal application of urea only slightly increased mean coconut leaf number at 8 and 12 MAP (Table 6). Mean coconut leaf number slightly decreased with the application of 300 g rock phosphate with a basal application of urea throughout the sampling period (Table 6).

Influence of rainfall on coconut nursery performance at NIFOR main station: Rainfall distribution at NIFOR main station for 9 years is indicated in Table 7. Highest amount of rainfall (469.6 mm) was recorded in the month of September, 2013 while the lowest amount (1.6 mm) was recorded in January, 2009.

DISCUSSION

Earlier experiments had suggested that it might not be profitable to apply fertilizers to coconut seedlings in the nursery as coconut seedlings treated to fertilizer applications were not remarkably different from the control[12]. In more recent studies however significant improvements have been obtained in coconut nursery seedlings receiving fertilizer applications over those without fertilizer applications[13,14]. According to Aondona *et al*.[13] seedlings that were treated with 28, 42, 56 and 72 g of NPK Mg fertilizer were significantly different from the control with respect to leaf area, plant height, number of leaves and stem girth while[14] observed that a single application of NPK 15:15:15 produced the highest dry matter and increased the leaf area of coconut seedlings over other treatment combinations and control. In this study, mean plant height of palms that received NPK 15:15:15 as basal dressing were generally higher than mean plant height of palms that received urea as a basal dressing. This could be attributed to the complementary effects of N, P and K with applied SRP compared to Urea which contains only N. In this study, values of leaf area were much lower than those reported by earlier workers like[10,12]. Eight MAP coincided with the period of less rainfall at NIFOR. The lack of significant difference observed in mean plant height at 8 MAP could be due to the low availability of moisture. The rock phosphate used for this study is water soluble with low nutrient-release in water (1.24%) when compared with 25.16% in mineral acid[15]. This is buttressed by the low amount of rainfall in the month of February at NIFOR main station which coincided with 8 MAP. This trend continued at 12 months after planting. Low moisture levels in plants are known to cause leaf wilting and death[16]. The implication of the findings from this study is that rock phosphate can be used to improve coconut seedlings. The study therefore recommends that rock phosphate used for the improvement of coconut seedlings should be applied in conjunction with NPK fertilizers. This is due to the poor performance of coconut seedlings when applied with urea and this coupled with poor solubility of rock phosphate in water are factors that could limit its use in Ultisols of Southern, Nigeria.

CONCLUSION

Rock phosphate as a source of phosphorus fertilizer for coconut nursery seedlings was evaluated at NIFOR main station with a basal application of NPK 15:15:15 and Urea. Results showed that the application of 200 g rock phosphate with a basal application of NPK 15:15:15 gave the best performance of coconut seedlings in terms of plant height, stem girth and leaf area. The study has shown that rock phosphate can be used to raise healthy and transplantable coconut seedlings in an Ultisol with minimal use of NPK fertilizer.

SIGNIFICANCE STATEMENT

This study has discovered that coconut nursery seedlings cultivated in a sandy acidic soil can be improved by application of rock phosphate combined with NPK 15:15:15. The study will help researchers and coconut farmers achieve healthy and transplantable coconut seedlings by minimal use of rock phosphate and NPK 15:15:15 fertilizer.

ACKNOWLEDGMENT

The authors are grateful to the Executive Director, the Director, Coconut Research and Development Department and Research and Management Committee (RMC) of the Nigerian Institute for Oil Palm Research (NIFOR) for funding this study through Project Grant NIFORCFP2013.

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