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Phosphorus Fertilization Influence on Economics of Production of Oil Palm (*Elaeis guineensis*) Seedlings

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Abstract: Increasing costs of soluble phosphate fertilizers and possibility of environmental pollution necessitate judicious choice of phosphorus (P) fertilizer, the quantity of which determines total fertilizer cost in crop production enterprises. As such, the trial to find out the suitability of rock phosphates was conducted to ensure economic returns to the growers and guarantee sustainable production. Polybag oil palm (*Elaeis guineensis*) seedlings were treated in two soil types (three replicates in RCBD) to three levels of P (0, 7.56 and 15.12 g P_2O_5 palm^{-1}) using single super phosphate, SSP (18% P_2O_5); Ogun rock phosphate, ORP (30% P_2O_5) and Crystalliser, CRYS (talc + Sokoto rock phosphate mixture) (21% P_2O_5) in 1998/1999. Plant vigour attributes (stem girth and leaf area) were evaluated at 3, 6, 9 and 12 Months After Planting (MAP). Phosphorus application of the three sources proved quite beneficial, as untreated plants were less vigorous than treated ones. Treatments shortened the period (by about 3 months) that seedlings had to grow prior to being transplanted or sold to other growers. Seedlings' responses to the sparingly soluble, cheap and readily available P sources (ORP and CRYS) were equal or better than to the soluble, expensive and less available SSP in both soils, guaranteeing net returns to the growers when the former are substituted for the latter. The studies revealed that the maximum returns (B:C = 1.12) were registered when ORP was applied at 7.56 g P_2O_5 palm^{-1}.

Key words: *Elaeis guineensis*, phosphorus, super phosphate, rock phosphates, Rhodic Palaudalf, Plinthic Tropudalf, benefit: cost ratio

INTRODUCTION

Oil palm (*Elaeis guineensis*) is a member of the distinctive and ancient family (Palmae-alternatively Arecaceae) of woody plants of the order Palmales that is sometimes called Principes. It is indigenous to the Nigeria coastal plain (Kajisa *et al*., 1997), having migrated inland as a staple crop, giving the highest yield of oil per unit area of any crop and producing two distinct oils, palm oil and palm kernel oil, both of which are important in world trade. Oil palm cultivation is part of the way of life-indeed it is the culture-of millions of people in Nigeria as it also provides palm wine. However, during the past decades the country has become a net importer of palm oil. In the early 1960s, Nigeria's palm oil production accounted for 43% of the world production, but nowadays it only accounts for 7% of total global output.

Contrary to the situation of the current oil palm 'heavyweights', Malaysia and Indonesia, whose production is based on large-scale monocultures, in Nigeria, 80% of production comes from dispersed smallholders who harvest semi-wild plants and use manual processing techniques. Several million smallholders (inter-cropping oil palm with food crops like cassava, yam and maize) are spread over an estimated area of 1.65 million ha in the southern part of the country.

In an attempt to emulate the success stories of Malaysia and Indonesia, Nigeria tried to implement large-scale plantations, which resulted in complete failures (Kajisa *et al*., 1997). Such were the cases of the 1960's Cross River State project and of the European Union (EU)-founded Oil palm Belt Rural Development Programme in the 1990's. This project included the plantation of 6,750 ha of oil palm within an area thought to be one of the largest remnants of tropical rainforest in Nigeria. In spite of local opposition, the project moved forward and EU funding was only discontinued in 1995, seven years after its approval.

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Oil palm is a heavy feeder for macronutrients, especially N, P and K and phosphate deficiency may be sufficiently acute to produce foliar symptoms. Increasing fertilizer costs and environmental pollution are the problems of major concern needing an urgent attention. The cost of purchasing nutrients is in the order P>K = N>S (FAO, 2004), indicating that fertilizer cost will be largely determined by the amount of P purchased (Hardy and Osmond, 2006; Zublena, 1991). There can also be big differences in the cost of P between the various P fertilizers. Careful choice of the P fertilizer is, therefore, an important factor affecting overall fertilizer costs. In order to have a solution to the above-mentioned issues, it is essential to go for judicious use of phosphate fertilizers. In a bid in this direction, the trial to find out the suitability of rock phosphates was conducted to ensure economic returns to the growers.

MATERIALS AND METHODS

Materials: Top 15 cm of two soil types (one Rhodic Palaudalf and the other Plinthic Tropudalf) from two locations in Nigeria (Epe in Lagos State and Ibadan in Oyo State) were collected, air-dried, passed through 2 mm sieve and prepared for nursery planting of oil palm seedlings. Ten kilograms of soil were weighed per polythene bag (40×35 cm) and replicated three times. A total of 54 bags were prepared and placed 46×46 cm on metal benches in an open space near the Agronomy Departmental Greenhouses at the Ibadan University, Nigeria. Three-month old seedlings (collected from the Nigeria Institute for Oil-palm Research, NIFOR) were grown in the polythene bags between August 1998 and June 1999 and treated to three P levels (0, 7.56 and 15.12 g P_2O_5 palm^{-1}), using three fertilizer sources (single super phosphate, SSP-18% P_2O_5; Ogun rock phosphate, ORP-30% P_2O_5 and Crystalliser, CRYS-talc and Sokoto rock phosphate, SRP mixture, 21% P_2O_5). Each of the 3×3 (=9) treatment combinations was replicated thrice in Randomised Complete Block Design (RCBD) and observations were recorded at 3, 6, 9 and 12 months on two plant vigour parameters (stem girth and leaf area). The data collected were analysed for statistical significance by analysis of variance (ANOVA) based on factorial arrangement in RCBD. Duncan Multiple Range Test (DMRT) was used to compare treatment means when an ANOVA showed significant differences among means.

RESULTS AND DISCUSSION

Effects of phosphorus sources and levels: Result summarised in Fig. 1 shows the effect of P-sources on leaf area of oil palm seedlings. Throughout the sampling period, oil palm seedlings grown on Soil A, (Rhodic Paleudalf) significantly ($p<0.05$) produced broader and larger leaves than those of Soil B (Plinthic Tropudalf). However, the responses among the P-sources (SSP, ORP and CRYS) were not significant in either of the soil types until 6 months of growth.

The oil palm seedlings showed large responses to applied P as can be seen in significant ($p<0.05$) increases in stem girth (Fig. 1). As from 6 months of growth, there were significant ($p<0.05$) differences among the P-sources in both soils. In Soil A, (Rhodic Paleudalf) ORP and CRYS treated oil palm seedlings were about the same in stem girth but significantly bigger than SSP treated and control plants. In Soil B (Plinthic Tropudalf), ORP treated oil palm seedlings produced the biggest stems, followed by CRYS and SSP treated ones in decreasing order while the control produced the smallest sized stems.

There were significant responses to the different P-sources applied. Without added P, stem girth of oil palm seedlings was much less. Application of P-fertilizer irrespective of source or rates significantly increased the stem thickness in both soils. Similar responses of oil palm to P-fertilization had been observed in Nigeria (Ataga, 1978) and in Malaysia (Zaharah *et al*., 1997). The better performance of ORP and CRYS over SSP is an indication of the enormous potential of these local phosphate rocks for direct use as P-fertilizers. This confirms the results reported by IRHO (1974) that phosphate rock treated oil palms had superior effect compared to annual triple super phosphate. Thus, the expectation that water soluble P-fertilizer should have superior effect over phosphate rock, was not supported by this finding.

It was observed that as from 3 months of growth, the largest leaves were recorded with the recommended application rate of 7.56 g P_2O_5 palm^{-1} while the plants receiving double the rate (15.12 g P_2O_5 palm^{-1}) produced leaves as narrow as the control.

Similarly, there were significant differences ($p<0.05$) among the different rates of P applied in both soils. The response to application rate of 7.56 g P_2O_5 palm^{-1} and 15.12 g P_2O_5 palm^{-1} was initially about the same. But as from 4 months of growth, 7.56 g P_2O_5 palm^{-1} application rate produced the biggest sized stems in both soils. Doubling the application rate (15.12 g P_2O_5 palm^{-1}) and control (0 P g P_2O_5 palm^{-1}) were statistically the same in size.

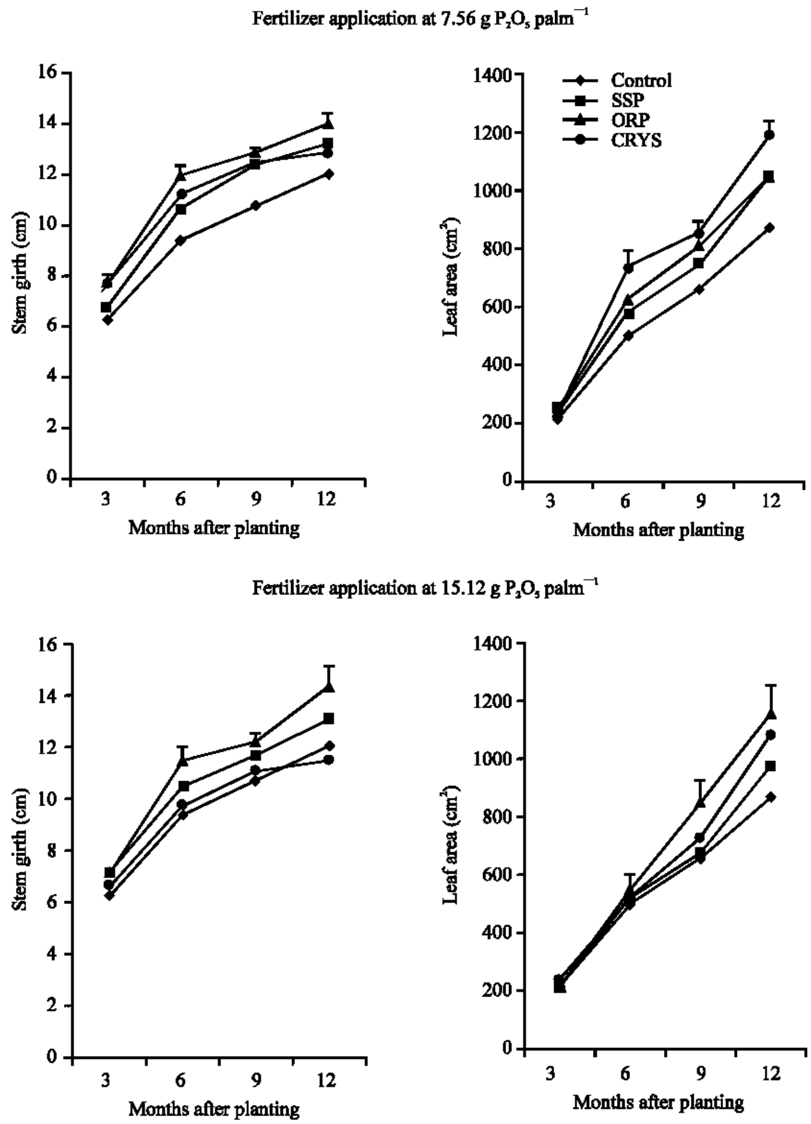

Fig. 1: Effect of fertilizer treatment on leaf area and stem girth of oil palm seedlings at successive growth periods (Pooled for two soil types)

The superior performance of recommended application rate (7.56 g P_2O_5 palm^{-1}) over the double dose (15.12 P_2O_5 palm^{-1}) in some of the growth parameters suggests that the recommended application rate of 7.56 g P_2O_5 palm^{-1} by NIFOR (1965; 1982) is adequate. This was consistent with the findings of Lucas *et al.* (1979) who also confirmed the recommended fertilizer rates by NIFOR but suggested that the frequency and time of application be reviewed.

The results of this investigation showed that using polybag oil palm seedlings as test crop, rock phosphates had higher availability and better crop response than super phosphate in acid soils. The behaviour of these P-sources in the two soils (Rhodic Paleudalf and Plinthic Tropudalf) is consistent with the findings of Obigbesan and Mengel (1981) and Fayiga (1998) that rock phosphates are useful fertilizers in acid soils. Obigbesan and Mengel (1981) also showed that solubility of single super phosphate is much better in more neutral soils compared with acid soils. Thus, phosphate ions released from it are probably strongly adsorbed by sexquioxides and thus become less soluble than rock phosphates. This could be responsible for its low performance.

Interaction effect: Effect of interaction among P levels, fertilizer sources and soil type was significant for the

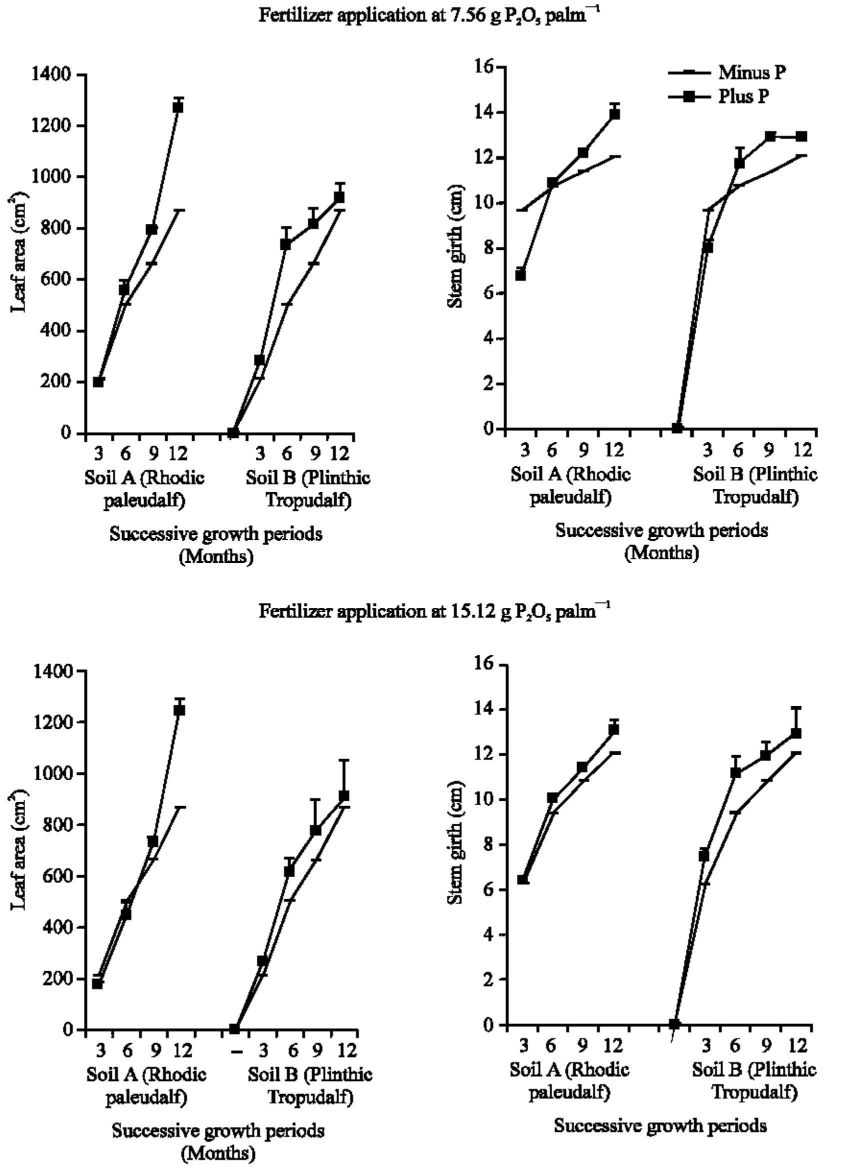

Fig. 2: Effect of phosphorus treatment (across phosphorus fertilizer sources) on leaf area and stem girth of oil palm seedlings grown in two soil types at successive growth periods

measures of plant vigour (Fig. 1 and 2). A scrutiny of the data revealed that P fertilization ensured the shortest period prior to seedlings' readiness to reach transplanting or market. To be ready for transplanting and sold to other growers, the oil palm seedlings (with stem girth ≥10.00 cm) had to grow for 9 months without P application (untreated/control) instead of 6 months with P application (Fig. 1).

Economics of production: An insight into Table 1 reveals that the cost of fixed inputs for the production of 1000 polybag oil palm seedlings is #92,000.00 without P treatment and #80,500.00 with P treatment. The comparison of different treatment combinations for their economic viability (Table 2) brings out the fact that the economically best combination was found to be the application of 7.56 g P_2O_5 palm^{-1} using ORP, which ensured a net return of #1.12 per naira investment. On the other hand, the least profitable treatment turned out to be without P application (B: C = 0.88), thereby emphasising the optimal supply of fertilizer P through the rock

Table 1: Cost of production for 1,000 oil palm seedlings (Fixed cost)

	Cost (#)	
Expenditure item	Without P treatment (9 months)	With P treatment (6 months)
Preparatory stage		
(a) 15 labour units @ #500.00 day^{-1} for topsoil collection, mixing fertilizer with soil and weighing soil (10 kg) into polybags	7,500.00	7,500.00
(b) 1000-10 kg capacity polybags @ #10.00 each	10,000.00	10,000.00
Planting		
(a) 1000 seedlings @ #30.00 each	30,000.00	30,000.00
(b) 5 labour units @ #500.00 day^{-1} for sowing	2,500.00	2,500.00
Inter-culture		
(a) 60 labour units @ #500.00 day^{-1} for weeding and irrigation	30,000.00	-
(b) 40 labour units @ #500.00 day^{-1} for weeding and irrigation	-	20,000.00
Overhead charges @15%	12,000.00	10,500.00
Total	92,000.00	80,500.00
Single super phosphate (18% P_2O_5) @ #44.00 kg^{-1}		
7.56 g P_2O_5 $palm^{-1}$-------------- 42.00 kg SSP/1000 palms --------- 1,848.00		
15.12 g P_2O_5 $palm^{-1}$------------- 84.00 kg SSP/1000 palms -------- -3,696.00		
Ogun Rock Phosphate (ORP)-30% P_2O_5 @ #32.00 kg^{-1}		
7.56 g P_2O_5 $palm^{-1}$-------------- 25.2 kg ORP/1000 palms ----------- 806.40		
15.12 g P_2O_5 $palm^{-1}$------------ 50.4 kg ORP/1000 palms ---------- 1,612.80		
Crystalliser (Crys)-20% P_2O_5 @ #38.00 kg^{-1}		
7.56 g P_2O_5 $palm^{-1}$------------- 37.8 kg Crys/1000 palms ----------- 1,436.4		
15.12 g P_2O_5 $palm^{-1}$------------ 75.6 kg Crys/1000 palms ----------- 2,872.80		
Cost of nitrogen (8.85 kg N 1000 $palms^{-1}$)		
19.67 kg urea (45% N) @ #62.00 kg^{-1}-------------------------------- 1,219.54		
Cost of potassium (25.20 kg K_2O 1000 $palms^{-1}$)		
42.0 kg muriate of potash (KCl)-60% K_2O @ #59.00 kg^{-1}-------- 2,478.00		

Table 2: Economics of production for 1000 oil palm polybag seedlings

Treatment (g P_2O_5 $palm^{-1}$)	Gross income (# 1000 $palms^{-1}$)	Expenditure (# 1000 $palms^{-1}$)	Net returns (# 1000 $palms^{-1}$)	B: C ratio
0	180,000.00	95,697.54	84,302.46	0.88
Single super phosphate				
7.56	180,000.00	86,045.54	93,954.46	1.09
15.12	180,000.00	87,893.54	92,106.46	1.05
Ogun rock phosphate				
7.56	180,000.00	85,003.94	94,996.06	1.12
15.12	180,000.00	85,810.34	94,189.66	1.10
Crystalliser				
7.56	180,000.00	85,633.94	94,366.06	1.10
15.12	180,000.00	87,070.34	92,929.66	1.07

Market rate of the produce @ #180.00 oil palm $seedlings^{-1}$

phosphates, particularly ORP. The present findings need to be considered along with the net returns obtainable with the use of other organic and organo-mineral fertilizers.

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