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Assessment on the Use of Highly Reactive Phosphate Rock for Immature Palms

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Abstract. A study was conducted to compare the effectiveness of a highly reactive phosphate rock (RPR) with non-reactive phosphate rock (non-RPR) for newly replanted oil palm. Parameters monitored were chlorophyll, vegetative measurements, and nutrient status in foliar and rachis samples. At thirty six months after planting (MAP), there were highly significant chlorophyll readings for RPR treatment as compared to non-RPR at 9 MAP until 21 MAP. For RPR, vegetative measurements such as girth size, frond length and petiole cross section showed significantly bigger at 36 MAP when compared to non-RPR. Analysis of foliar and rachis nutrient status also indicated that the RPR treatment showed much better results. Early result of the first 6 months FFB yield indicated positive response of RPR which gave 26% an extra yield. These preliminary results further showed that the highly reactive phosphate rock gave better vegetative growth and early yield of young oil palm.

Keywords: Phosphate Rock, Highly Reactive Phosphate Rock, Phosphate response.

1. Introduction

Phosphate (P) is a major element required for palm growth especially for root development during the early stage. It is also equally important for the yielding stage through the fundamental roles in enzymatic reactions which give full expression of Nitrogen (N), Potassium (K) and energy transformation. However, the reactivity of rock phosphate, soil type, crop species and their interaction would influence the agronomic effectiveness. Phosphate rocks from countries like Jordan, Morocco, Tunisia, China and United States of America which are different in their mineralogical properties, because their solubility and availability to differ too [1]. Various P fertilizers have been evaluated for oil palm under nursery and field conditions [2]. Biological characteristics evaluated were plant growth, dry matter yield and P uptake. High reactive phosphate from Peru has proven to be one of the most reactive [3] as direct application P fertilizers. It was found in beds in northern Peru as a fine (60% < 150 m) spherical sand and has proven to be one of the most reactive [4] and it is greater than North Carolina's phosphate rock (NCPR) from the United States of America and Gafsa phosphate rock (GPR) from Tunisia [5]. This highly reactive rock phosphate would therefore appear to offer considerable promise as a direct application P fertilizer. Since the study of this highly reactive phosphate rock source especially in this country is limited, this study is important to evaluate the effectiveness the early palm growth and FFB yield.

2. Material and Method

Table 1 shows that the different rate of phosphate fertilizer that have been applied for RPR and non-RPR treatments during the first and second year. Data from 12 recording palms (6 palms x 2 rows) were collected

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from each plot and the parameters that have been measured were vegetative in every 6 months. Regular field mantainence have been done by estate.

Table 1. Detail of phosphate treatment is as follows:-

Treatment		% P_2O_5	% CA Soluble	Rate (kg/palm) Year 1	P_2O_5 (kg/palm)	Rate (kg/palm) Year 2	P_2O_5 (kg/palm)
T1	**Non- RPR**	33.0	9.0	1.13	0.37	1.83	0.60
T2	**RPR**	31.6	15.8	1.16	0.37	1.90	0.60

Note: Other elements including N, K, Mg and B was given equally according to estate standard practice for both the treatments.

Trial design and other particulars are described below:-

Planting date:	1st January 2010	**Planting material:**	FELDA Yangambi DxP (ML 161 crosses)
Location:	Phase B, FASSB Jengka 25, Pahang, Malaysia	**Soil type:**	Chempaka series
Experimental design:	Randomised Complete Block Design (RCBD)	**Terrain:**	Flat to undulating
Replication:	2	**Stand per hectare:**	148 palms per hectre
Treatment:	2	**Parameters:**	Vegetative growth including chlorophyll girth size, no of fronds, length*, leaf no*, width and thickness of petiole*, foliar and rachis analysis*.
Plot size:	4 rows X 8 palms		
Data Analysis:	T-test using Statistical Analysis System (SAS)	**Duration of trial:**	3 years (2010-2012)

3. Result and Discussion

3.1. Vegetative Measurements

Result of SPAD chlorophyll showed in Table 2 indicated that the RPR have significantly highest reading ($p \leq 0.01$) at 9 Month After Planting (MAP) until 21 MAP. While at 36 MAP, RPR showed slightly higher reading which was 70.81 SPAD as compared to non-RPR which was 68.68 SPAD, although statistically there was no significant difference. For RPR, highest reading for chlorophyll was at 21 MAP which was 79.13 SPAD as compared to non-RPR which was 73.00 SPAD. Total results showed that there was an increasing trend of chlorophyll reading starting from 7 MAP until 36 MAP**.** It has been reported by many researchers that P status in foliar has a significant influence on leaf photosynthesis and carbon metabolisms in plants [6].

Table 2. Chlorophyll reading starting from 7 to 36 months after planting (MAP)

	7 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	36 MAP
Non-RPR	42.31	50.07	36.62	60.06	64.76	73.00	68.68
RPR	39.49	58.03	54.95	67.44	70.56	79.13	70.81
F-Value	**1.08ns**	**2.24****	**1.34****	**14.06****	**4.36****	**1.62****	**1.42ns**

In terms of vegetative measurements at 36 MAP as shown in Table 3, statistically RPR showed a highly significant difference for girth size parameter which was 63.95 cm as compared to non-RPR which was only 57.25 cm. For frond length, there was significant difference for RPR which was 332 cm and 293 cm for non-RPR. Leaf number showed significant difference at 36 MAP which was 119 as compared to non-RPR which was 104. Measurements of petiole cross section parameter shows that there was significant difference statistically which was 2.71 cm for RPR and 2.51 cm for NRPR. Generally, both P sources fertilizers did not show any significant results during the first 6 months after planting (MAP). This indicates that during the initial growth period, very little response to P fertilizer sources occurred [1].

More than 90% of the total P present in the palm was derived from the fertilizers tested at all stages of growth, showing the inadequate P supply present in the soil used [1]. Soils in Malaysia are very deficient in P and plants cannot grow to maturity without P fertilizer application [7] and [8]. It has been reported that that reactivity of phosphate rock determines its potential as a direct fertilizer, and the more reactive the phosphate rock [9], the greater its agronomic effectiveness [10].

Table 3. Vegetative measurements starting from 7 to 36 months after planting (MAP).

Treatments	Girth size (cm)	Fronds no	Fronds no 9				LAI (m^2)	Dry Weight (kg)
			Fronds length (cm)	Leaf no	Petiole width (cm)	Petiole depth (cm)		
Non-RPR	57.25	44.92	293.00	107	4.40	2.51	2.83	1.35
RPR	63.95	43.75	332.00	119	4.45	2.71	3.42	1.45
F-Value	**8.35****	**1.56^{ns}**	**1.41****	**1.62****	**1.64^{ns}**	**1.11***	**1.16****	**1.04^{ns}**

*P≤0.05 **P≤0.01 ns not significant

3.2. Foliar and Rachis Nutrient Status

Nutrient status of P foliar did not show any significant difference statistically throughout the experiment. However treatment with RPR showed slightly higher results for total N, P and K at 36 MAP in foliar nutrient status when compared to non-RPR as shown in Table 4. For total nitrogen (N), RPR showed 6% higher result which was 2.60 % on dry matter as compared to NRPR which was 2.44 % on dry matter. Phosporous (P) result for RPR was 0.159 % on dry matter which was 4 % higher as compared to non-RPR which was 0.153 % on dry matter. The highest difference for RPR was the value of Potassium (K) which was 11 % higher as compared to non-RPR.

Table 4. Foliar Nutriens Status for N, P, K and Mg at 36 Months After Planting (MAP).

Treatments	Total N (%)	P (%)	K (%)	Mg (%)
Non-RPR	2.44	0.153	1.09	0.28
RPR	2.60	0.159	1.21	0.26
% Over non-RPR	**106**	**104**	**111**	**94**

P nutrient status in rachis showed an increasing trend starting at 18 MAP, 24 MAP and 36 MAP respectively higher at 4%, 25% and 63% of RPR over treatment with non-RPR as in Fig. 1. According to Foster (2012), rachis analysis was the best indicator of total nutrient uptake by the palm. It was indicated that the availability of P with RPR was more available to the palm and effectively taken. The chemical reactivity or solubility of phosphate rocks was a measure of the phosphate rock ability to release P for plant uptake.

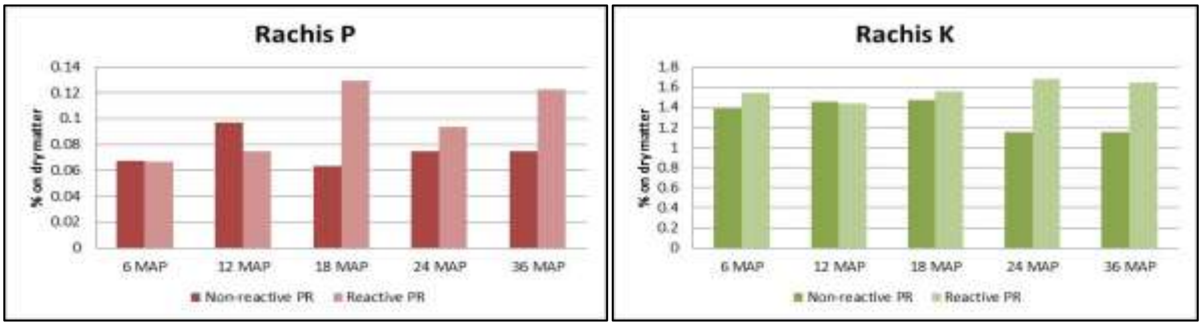

Fig. 1: P and K nutrient status in rachis.

3.3. FFB Performance

The available bunch was census and the yield was recorded at first year harvesting (till June 2013). Table 5 show that there was significant difference for RPR during April 2013 which was 0.86 tonne/ha compared with non-RPR which was 0.22 tonne/ha. However there was no significant difference among the treatment in term of total FFB production from January until June 2013, but FFB yield with the treatment of RPR (3.90 tonne/ha) was higher by 26% as compared to non-RPR at 3.09 tonne/ ha as in Fig. 2. The relative agronomic effectiveness (RAE) of the P fertilizers was computed, % RAE = FFB yield (RPR)/ FFB yield (Non-RPR) x 100.

3.4. Economic Analysis

Comparison of the material cost between non-RPR and RPR has been calculated for the first and second year of manuring according to estimated fertiliser price in 2013. The calculation of material cost was based on the rate of fertiliser given. Based on Table 6, the price of non-RPR in 2013 were RM 550/ tonne while the price of RPR was RM 680/ tonne. Without considering other fertiliser costs (N, K, and Mg), material cost for RPR for first two years manuring are RM 283/ ha compared with non-RPR at RM 222/ ha. For the first six months of yield, (Jan - Jun 2013) there was 0.81 tonnes/ ha additional yield and the profit with that increment of FFB was RM 330.

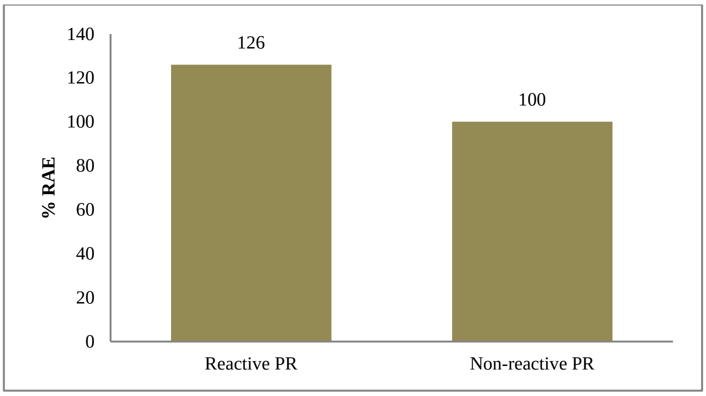

Fig. 2: Percentage of Relative Agronomic Effectiveness (RAE).

Table 5. Yield Results for non-RPR and RPR in the year 2013.

Treatment	Month						Cumulative
	Jan (t/ha)	Feb (t/ha)	Mar (t/ha)	Apr (t/ha)	May (t/ha)	Jun (t/ha)	Jan-Jun (t/ha)
Non-RPR	0.09	0.50	0.48	0.22	0.76	1.03	3.09
RPR	0.15	0.28	0.95	0.86	0.93	0.73	3.90
F-Value	**2.03^{ns}**	**1.65^{ns}**	**2.87^{ns}**	**4.36****	**1.28^{ns}**	**2.78^{ns}**	**2.03^{ns}**

*P≤0.05 **P≤0.01 ns not significant

Table 6. Cost effectiveness of rock phosphate for 2 years application

Treatments	Fertilizer cost (RM/ ha)	Fertilizer Rate (tonne/ ha)	Fertilizer Cost (RM/ ha)	First year FFB (tonne/ha)	Profit with increament of FFB$^{\pm}$ (RM)
Non-RPR	550*	0.403	222	3.09	-
RPR	680*	0.416	283	3.90	330
Difference			61	0.81	

$^{\pm}$Estimated 2013 FFB price – RM 483/ tonne *2013 fertilizer price

4. Conclusion

The results to date indicated that RPR gave superior response in term of vegetative palm growth as well as the early FFB yield. A longer term of yield monitoring will be required to confirm the finding. However, it can be concluded that the reactive phosphate rock (RPR) showed a better economic potential source of P compared to the conventional low reactive phosphate rocks (Non-RPR).

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