MAXIMIZING THE POTENTIAL OF PHOSPHATE FERTILIZERS FOR INCREASING MATURE OIL PALM YIELD

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Malaysian soils, like most tropical soils, are highly weathered, acidic and inherently low in phosphorus (P) but with high P-fixing capacities. High rates of P fertilizers are required to overcome the P-fixation, mainly due to high Al and Fe oxides and hydroxides in the clay fraction (Ng, 1986).

P is one of the major plant nutrients required for good growth and production of oil palm. Studies have shown that P has synergistic effects with nitrogen (N) and potassium (K) on oil palm yield. In oil palm fertilizer trials in Peninsular Malaysia, testing high rates of fertilizers, large responses to N and K fertilizers were obtained but the full responses were only obtained with adequate P fertilization (Foster *et al*., 1988).

This article will serve as a guide to the importance of applying the optimum rates of P fertilizer together with N and K fertilizers and the technique used to maximize the potential of the P fertilizer to increase FFB yield in mature (7-20 years old) oil palm replants, particularly on inland and coastal soils of Malaysia.

FIELD EVALUATION

Several field trials and an incubation study on oil palm response to P fertilizer had been conducted by MPOB (then PORIM) and the oil palm industry since the 1970s. In the field trials, which included ten on applying P fertilizer to mature oil palm, the data were analysed in two time periods. Six of them were laid on inland soils derived from sedimentary rock (or associated colluvium) and the remainder on coastal soils derived from riverine and marine alluvium.

Data from the trials were fitted into response equations (Foster *et al*., 1988). The responses to P fertilizer predicted by the equations at control and optimum levels of other fertilizers were compared for the different soils and time periods. The first was for palms on 7 up to 12 years old, and the second for 12 to 18 years old palms.

In the incubation study (a closed system), the effects of empty fruit bunch (EFB) treatments on the dissolution of P from phosphate rocks (Tunisian and Christmas Island), and soluble triple superphosphate on a Rengam series soil were investigated (Zulkifli *et al*., 2003).

OPTIMUM P FERTILIZER RATES

The oil palm FFB yield responses to different rates of P fertilizer on inland and coastal soils in the two periods were studied. The data conclusively showed positive yield responses to P fertilizer for both soil types (*Figures 1* and *2*).

The response to phosphate rock (CIRP) was generally profitable up to at least 3.0 - 4.0 kg palm^{-1} yr^{-1} on inland soils (*Figure 1*).

On coastal soils, the response to CIRP was generally profitable up to 2.0 – 3.0 kg palm^{-1} yr^{-1} with only N (and not K) fertilizer needed (*Figure 2*).

Rajaratnam *et al*. (1976) had earlier recommended for oil palm replants, that the P fertilizer rate for maximum yield was about 2 kg palm^{-1} yr^{-1} and the economic rate about 1.0 kg CIRP palm^{-1} yr^{-1}.

However, with the current advanced and improved high yielding palms, in addition to improved agro-management practices and increased N and K fertilization, P requirement by the palms also increased accordingly. This was more evident on inland and marginal soils and areas under oil palm for three or four generations.

P FERTILIZER REQUIREMENTS WITH TIME

For inland soils, there was no indication whatsoever of any reduction in the P fertilizer require-

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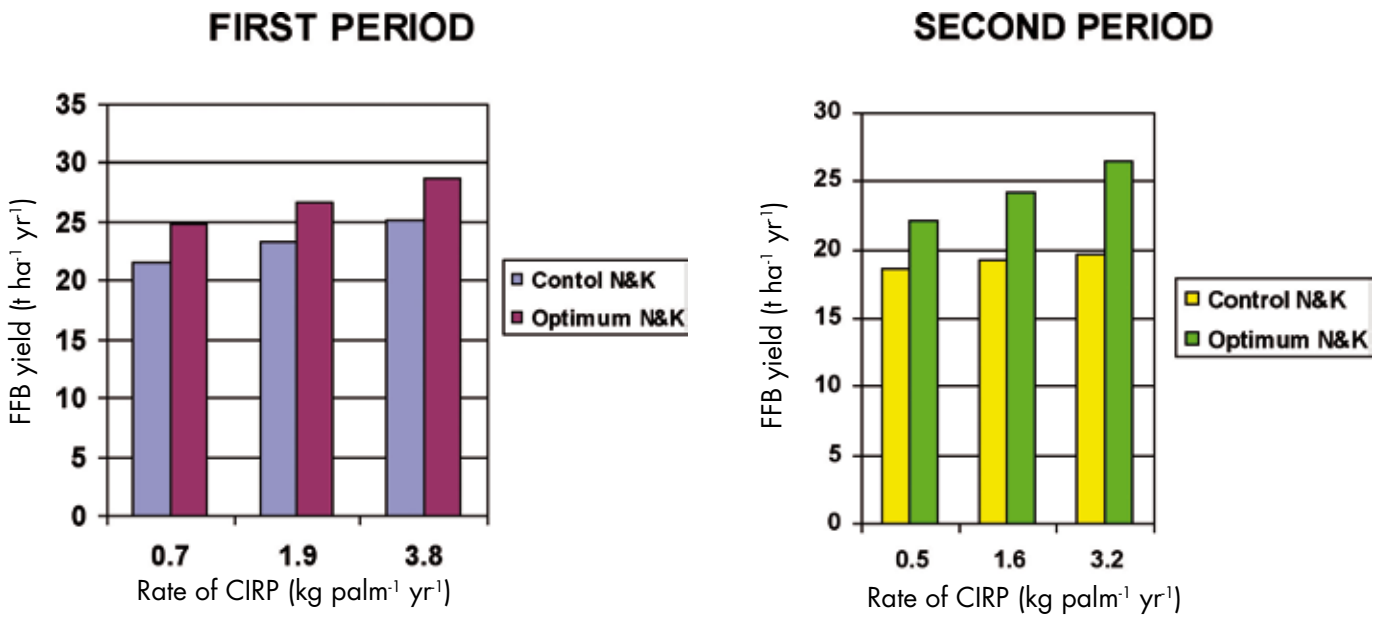
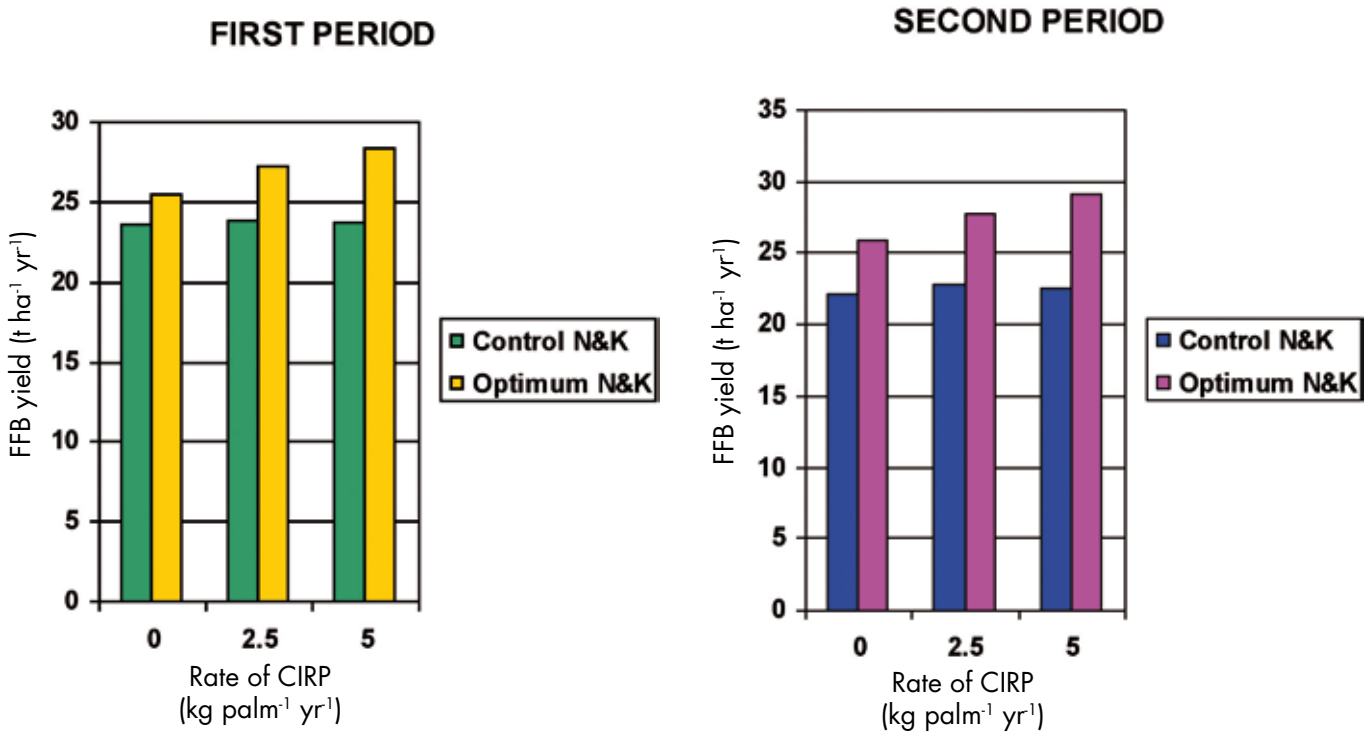


Note: First period refers to palms of 7-12 years-old, and second period palms of 12-18 years old

Figure 1. Effects of CIRP application on FFB yield on inland soils (two different periods).



Note: First period refers to palms of 7 to 12 years old, and second period palms of 12-18 years old.

Figure 2. Effects of CIRP application on FFB yield on alluvial soils (two different periods).

TABLE 1. AMOUNT OF P DISSOLVED AND PERCENT OF P DISSOLUTION (after six months incubation)

P source	P dissolved (mg kg^{-1} Soil)	% Dissolution*
TSP	569a	94.8
TSP + EFB	571a	95.2
TPR	188b	31.3
TPR + EFB	194b	32.3
CIPR	159d	26.6
CIPR +EFB	174c	29.0

Notes: *% Dissolution of P = P Dissolved /P added x 100%.
Values in columns followed by same letter are not significantly different at the 5% level by DMRT.

ment by the replants with time due to build-up of residual P in the soil (*Figure 1*).

On coastal soils (*Figure 2*), the response to P fertilizer tended to increase (rather than the expected decrease) with time.

SYNERGISTIC EFFECTS OF N AND P FERTILIZERS

The results also demonstrated that on inland soils, full P response depended on adequate N fertilization, particularly in the later years. Conversely, no response to N fertilizer was obtainable if P was inadequate. It is therefore strongly recommended that high rates of P fertilizer be applied in order to maximize the benefit from the more expensive N fertilizer (*Figure1*).

On coastal soils, response to P fertilizer was observed if N fertilizer was also applied. Conversely, the response to N fertilizer was severely restricted if P fertilizer was not applied (*Figure 2).*

OPTIMUM P LEVEL IN LEAF AND SOIL

On inland soils, the optimum leaf level was approximately 0.165% regardless of palm age and increased P fertilization is recommended if the level is lower (Foster *et al*., 1988).

In addition, a very strong response to P fertilizer can be expected if soil extractable P in the weeded circle is 15 ppm P, and no response likely if 150 ppm.

On coastal soils, neither the leaf nor soil P level was of any use in indicating the P fertilizer requirement.

BIOMASS ADDITION ENHANCES P DISSOLUTION

In the incubation study, palm biomass (EFB) enhanced the dissolution of PR fertilizers (Zulkifli *et al*., 2003). As shown in *Table 1*, addition of oil palm biomass reduced P sorption by 45%-50% as compared to the control (no biomass).

The study suggests that application of organic residues can reduce the amount of P sorbed by the soil, largely through ligand reactions on Fe or Al oxides and hydrous oxides. The addition of palm residues can substantially reduce the P sorption capacity of the soil.

ECONOMIC EVALUATION

A study on the returns to investment (ROI) as a measure of the performance or profitability of applying P fertilizer was done (Mohd Nasir *et al*., 2005). On coastal soils, the best returns were obtained with application of 3.0 kg $palm^{-1}$ yr^{-1} CIRP equivalent with a ROI of 2.74. However, on inland soils, the highest net return was obtained from application of 4.5 kg $palm^{-1}$ yr^{-1} CIRP equivalent with ROI of 2.67.

CONCLUSION

With the current planting of high yielding materials and high inputs of N and K fertilizers, P fertilization for mature oil palm has to be increased to achieve the maximum potential yield of the palms.

Field studies showed that the P fertilizer requirement by oil palm replants on the poorer inland

soils is high and does not reduce with time. Similarly, on coastal soils, adequate P fertilizer needs be applied in order to obtain full response from N fertilizer.

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