ORGANIC BIOMASS IN ENHANCING P FERTILIZER EFFICIENCY ON RENGAM SOIL SERIES

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Phosphorus (P) deficiency is a major limiting factor in many acid Malaysian soils. The amount of P in these soils are either inherently low or are fixed in forms that are unavailable to plants. Most studies demonstrated that more P is required on inland soil than the coastal soils in order to achieve a reasonable yield. High P rate is needed to overcome the high P-fixation, mainly due to high iron and aluminium oxides and hydroxides content in the clay fraction (Chan, 1982; Ng, 1986; Goh and Chew, 1995).

Studies on Rengam soil series showed that 1 kg phosphate rock (PR) palm^{-1} was needed to produce an FFB yield of 22 t ha^{-1}. However, the economic optimal PR rate of 3 kg palm^{-1} had raised FFB by 10% to 24 t ha^{-1} (Foong *et al.*, 2001). Therefore, a strong residual effect implied that high PR is needed to sustain higher yields.

P fertilization builds P stocks (sorbed-P) in oil palm plantation. The P availability to oil palm can be enhanced by incorporating organic biomass [soil covers, empty fruit bunches (EFB) and palm residues] together with P fertilizers. This would also indirectly influences soil pH, moisture and various fractions of soil P.

EXPERIMENTATIONS

An incubation study (closed system) was conducted to investigate the effects of organic biomass (empty fruit bunch) on the dissolution of P fertilizers and various fractions of P in the soil. Two types of phosphate rocks, namely Gafsa (GPR) and Christmas Island (CIPR), and a soluble triple superphosphate (TSP) were used with and without addition of organic biomass on a Rengam soil series.

Fractions of P (AlFe P, occluded P, Ca P, organic P and microbial biomass P) and the amount of P dissolved (ÐP) from added fertilizer were also measured on a replanting experiment, on Rengam soil series at Kluang (Khalid *et al.*, 2001). The effect of palm biomass on P availability was investigated after three years of replanting. The diagrammatic representation of changes in soil P pool and processes involved in the soil treated with P fertilizer and organic biomass is shown in *Figure 1*.

FINDINGS

The dissolution of P fertilizer and subsequent distribution of soil P fractions in Rengam soil series were affected by types of P fertilizer and application of EFB. The highest percentage P dissolution values were found in soil treated with water-soluble TSP (with and without EFB), because it is most soluble (*Table 1*). This was followed by GPR and CIPR (with and without EFB). CIPR with EFB showed greater amount of P dissolved, compared with TSP and GPR. These indicate that the reactivity, amount and the interaction of P with EFB influence the dissolution of P and soil P fractions.

More P was dissolved from water-soluble TSP added alone and shifted to plant-available P, NaOH P and occluded P (*Table 2*). However, Ca P from undissolved PR formed the largest P fraction in soil. The Ca P values suggest that CIPR formed higher residual P than GPR because CIPR is less reactive. In the longer term, Ca P may be an important P fraction for sustainable oil palm production.

Other factors that enhance further dissolution of P when applied with EFB are the Ca-sink size and P-sink size. Soluble organic acids produced as a result of microbial and chemical transformations of organic biomass are expected to form metal complexes with Al and Fe which readily react with P and eventually release the adsorbed P, which probably shifts to plant-available P or to the organic P pool. The finding indicates that adding organic biomass together with the PR fertilizer would continuously enhance the dissolution of PR in the soil over time compared with soil that added P fertilizer alone.

At Kluang, the palm residues decreased P sorption by 45%-50% (*Table 3*), compared to control. These results suggest that organic residues probably reduced the

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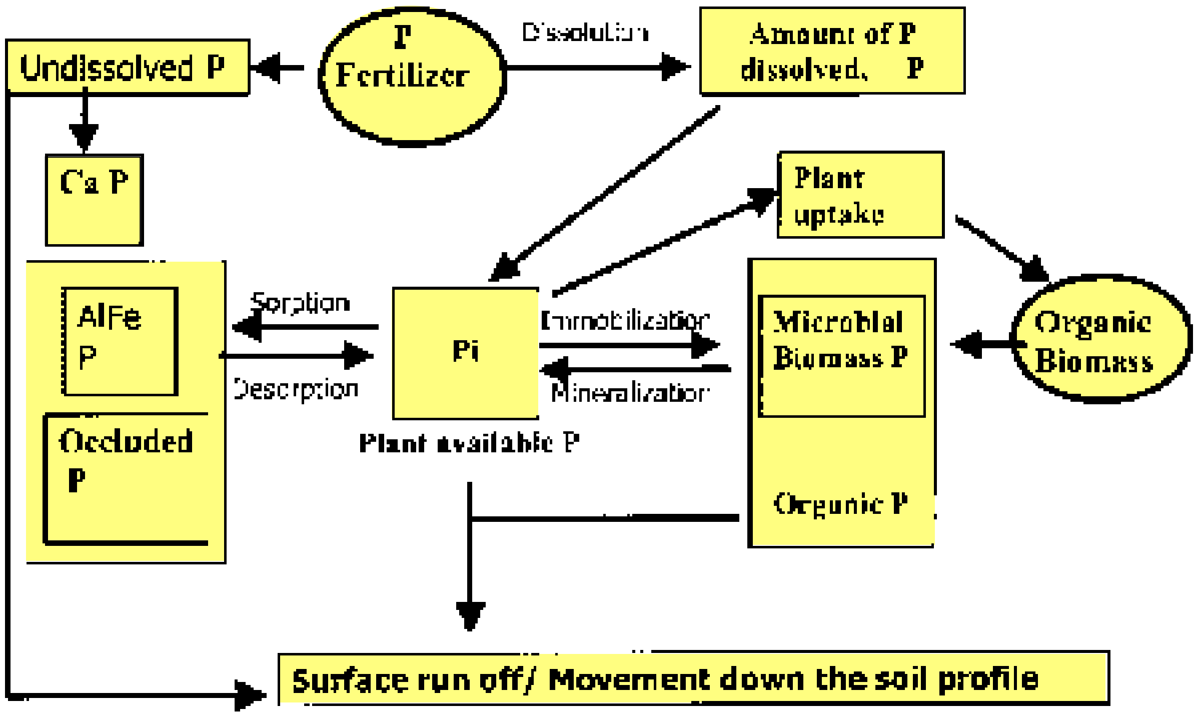

Figure 1. Diagrammatic representation of changes in soil P pool and processes involved in soil treated with P fertilizer and organic biomass.

TABLE 1. AMOUNT OF P DISSOLVED (ĐP) AND PERCENT DISSOLUTION OF P FERTILIZER AFTER SIX MONTHS OF INCUBATION WITH AND WITHOUT EMPTY FRUIT BUNCH (EFB)

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

Notes:
* Percent dissolution of P materials = (ĐP / P added) x 100.
TSP - triple super phosphate.
CIPR - Christmas Island phosphate rock.
GPR - Gafsa (Tunisia) phosphate rock.
Values in columns followed by the same letters are not significantly different at the 5% level, as determined by Tukey's Studentized Range.

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

In the long-term, biomass plays an important role in P cycling. A large amount of total P (28 kg P ha^{-1}) can still be detected at three years, after an initial addition of palm biomass containing 58 kg P ha^{-1}.

BENEFITS

The benefits include:

- because of the understanding of P dynamics, N and K interactions at a high yield level is achieved; and

- provide basic understanding on processes and P pools that are efficiently involved in the P cycle with better exploitation of fixed P through application of plant residues sorption-desorption processes and mineralization and immobilization processes.

CONCLUSION

- Recycling organic biomass (EFB, palm residues, pruned fronds) improves utilization of P through dissolution and solubility of P fertilizer;

TABLE 2. EFFECT OF ORGANIC BIOMASS AND P FERTILIZER ADDITION TO SOIL ON FRACTIONS ($mg\ kg^{-1}$ soil) OF SOIL P, OVER A PERIOD OF SIX MONTHS OF INCUBATION

P Source	Pi	AlFe P	Ca P	Occluded P	Organic P	Microbial biomass P	Total P
Control	4.90g	21.4g	5.50g	10.2e	15.5e	1.10e	63.5g
EFB	7.4f	22.2g	6.5g	10.9e	35.0d	5.90d	90.9f
TSP	162a	260a	53.1f	125a	75.0c	7.70c	678cd
TSP+EFB	142b	227b	82.5e	97.0b	75.0c	33.5a	694b
GPR	100c	133c	256b	96.4b	86.5c	7.10cd	686c
GPR+EFB	74.5d	120f	233c	86.5c	152a	31.2a	703a
CIPR	49.4c	154c	280a	86.1c	71.3c	6.90cd	673d
CIPR+EFB	51.7e	145d	212d	82.1d	120b	28.1b	690bc

Note: Values in columns followed by the same letters are not significantly different at the 5% level, as determined by Tukey's Studentized Range.

TABLE 3. AMOUNTS OF P SORBED AT A SOIL SOLUTION EQUILIBRIUM P CONCENTRATION (0.2 $mg\ litre^{-1}$) THREE YEAR AFTER ADDITION OF PALM BIOMASS

Treatment	P sorbed (at a soil solution equilibrium P concentration of 0.2 $mg\ litre^{-1}$, $mg\ P\ kg^{-1}$ soil)	P desorbed
Pulverized	142c	11.3a
Shredded	136c	9.1b
Partially-burnt	172b	7.2c
Control	261a	6.8c

Note: Values in columns followed by the same letters are not significantly different at the 5% level, as determined by Tukey's Studentized Range.

- Fractionation of P in soil amended with plant biomass gives an indication the long-term processes and transformations of these various fractions of P in soil; and

- Estimates of plant uptake of P and losses through leaching and erosion are also needed to obtain a better picture of P cycling in the soil amended with plant residues.

RECOMMENDATION

- Recycle of organic biomass to enhance P availability will allow the effect of N and K for higher yield to be achieved; and

- Adding of EFB at 25 t ha^{-1} yr^{-1} and PR at 3 kg $palm^{-1}$ yr^{-1} is recommended to improve P utilization.

REFERENCES

CHAN, K W (1982). Phosphorus requirement of oil palm in Malaysia: fifty years of experimental results. *Phosphorus and Potassium in the Tropics* (Pushparajah, E and Sharifuddin, H A Hamid eds.). Malaysian Society of Soil Science, Kuala Lumpur. p. 395-423

FOONG, S F; LEE, C T; HII, J M and ISMAIL, H (2001). Effect of various sources of phosphate rocks on oil palm yield. *Kemajuan Penyelidikan Bil. 38*: 33-43.

GOH, K J and CHEW, P S (1995). Direct application of phosphate rocks to plantation tree crops in Malaysia. International Fertilizer Development Centre (IFDC).

KHALID, H; ARIFFIN, D; ZIN, Z Z and A TARMIZI, M (2001). *MPOB TT No. 101*. MPOB, Bangi.

NG, S K (1986). Phosphorus nutrition and fertilization of oil palms. *Oleagineux, 41 (7)*: 307-313.

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