Management of Phosphorus and Organic Matter on an Acid Soil in Jambi, Indonesia

Pengelolaan Fosfor dan Bahan Organik pada Tanah Masam di Jambi, Indonesia

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ABSTRAK

A field experiment was conducted at Pauh Menang village, Jambi province, to assess crop and soil response to P fertilization, compare inorganic and organic sources of P, and assess the interactions between these sources. The experiment employed an incomplete factorial combination of six levels of inorganic P (0, 19, 38, 57, 76 and 95 kg P ha^{-1} as SP-36), two organic matters (FYM and stylo), and lime, laid out in a randomized complete block design with four replicates. The experiment was carried out over four seasons, from rainy season 1997/1998 until dry season 1999, however, the second crop failed due to severe drought. Under limed conditions, application of SP-36 at 38-kg P $ha^{-1}crop^{-1}$ increased soil P content. Repeated application of SP-36 resulted in accumulation of residual P and built up the P status of the soil well above 100 mg P kg^{-1} soil. The application of SP-36 in combination with OM, stylo or FYM, did not produce higher Colwell P contents in the soil compared with application of inorganic P alone. Grain yields of all corn crops increased significantly from about 0.5 to 3.5 t ha^{-1} with application of inorganic P at about 57 kg P ha^{-1}. The amount of P fertilizer required to obtain 85% relative yield decreased from about 62 to 40 to 28 kg P ha^{-1} for crop 1 to crop 3 and to crop 4, providing evidence of the residual effect of P fertilization. The direct use of RP at 42.6 kg P $ha^{-1}crop^{-1}$ was less effective than the readily soluble inorganic SP-36 at 38 kg P ha^{-1} $crop^{-1}$. Liming increased and maintained corn grain yields significantly. Application of OM as FYM or stylo in combination with SP-36 or RP did not resulted in synergistic interactions, with greater increases in yields. The introduction of an erect and fast growing stylo, *Stylosanthes guyanensis* cultivar CIAT 184, in the cropping system offers a good opportunity to improve fertility of acid soils. The high biomass yield of stylo, ranging from 0.8 to 4.9 t ha^{-1} per cutting, can be fed directly to cattle or sun-dried, ground and mixed with other materials to enrich feed concentrate. Widespread adoption of this legume would enhance cattle rearing, which in turn would produce more FYM as a source of organic P fertilizer .

ABSTRAK

Sebuah percobaan lapang telah dilaksanakan di Desa Pauh Menang, Propinsi Jambi, untuk mempelajari respon tanah dan tanaman terhadap pemupukan P, membandingkan sumber-sumber P anorganik dan organik, dan mempelajari interaksi dari kedua sumber P tersebut. Percobaan menggunakan kombinasi tidak lengkap dari enam tingkat dosis P anorganik (0, 19, 38, 57, 76 dan 95 kg P ha^{-1} sebagai SP-36), dua bahan organik (FYM dan stylo), dan kapur, dan diletakkan di lapang dengan rancangan acak lengkap dalam empat ulangan. Percobaan dilakukan selama empat musim, dari musim hujan 1997/1998 sampai musim kering 1999. Tetapi tanaman kedua gagal karena sangat kekeringan. Pada perlakuan dengan kapur, pemberian SP-36 (2) pada 38-kg P ha^{-1} $tanaman^{-1}$ meningkatkan kandungan P tanah. Pemberian SP-36 yang berulang-ulang menghasilkan penimbunan residu pupuk P dan meningkatkan status P tanah jauh di atas 100 mg P kg^{-1} tanah. Pemberian SP-36 dalam kombinasi dengan bahan organik, stylo atau pupuk kandang, tidak menghasilkan kandungan Colwell P dalam tanah yang lebih tinggi dibandingkan dengan pemberian pupuk P anorganik saja. Hasil biji jagung dari semua tanaman meningkat secara nyata dari 0,5 ke 3,5 t ha^{-1} dengan pemberian P anorganik sebanyak 57 kg P ha^{-1}. Jumlah pupuk P untuk memperoleh hasil relatif 85% menurun dari 62 ke 40 ke 28 kg P ha^{-1} untuk tanaman ke 1, ke tanaman ke 3 dan tanaman ke 4, yang merupakan bukti adanya pengaruh residu pemupukan P. Penggunaan fosfat alam secara langsung dengan dosis 42,6 kg P $ha^{-1}tanaman^{-1}$ kurang efektif dibandingkan dengan SP-36 dengan dosis 38 kg P ha^{-1} $tanaman^{-1}$. Pengapuran secara nyata meningkatkan dan mempertahankan hasil jagung. Percobaan ini menunjukkan bahwa pemberian bahan organik pupuk kandang atau stylo yang dikombinasikan dengan SP-36 atau pupuk fosfat alam tidak menghasilkan interaksi sinergis dengan peningkatan hasil yang besar. Pengenalan stylo yang tumbuh tegak dan cepat, *Stylosanthes guyanensis* cultivar CIAT 184, ke dalam pola tanam di desa ini menunjukkan adanya kesempatan yang baik untuk memperbaiki kesuburan tanah masam. Hasil biomasnya yang tinggi, berkisar antara 0,8 sampai 4,9 t ha^{-1} setiap kali pangkas, dapat diberikan langsung sebagai makanan sapi atau dikeringkan, digiling dan kemudian dicampur dengan bahan-bahan lain untuk rneningkatkan mutu konsentrat pakan ternak. Penanaman legum ini secara meluas akan mendorong pengembangan ternak, sehingga produksi pupuk kandang sebagai pupuk sumber P juga akan meningkat.

INTRODUCTION

Most fertilizer use in Indonesia has been for food crops, mainly irrigated lowland rice. Fertilizer use for upland crops is still limited, although upland crops have great potential as alternative sources of carbohydrate and protein. With the need to increase agricultural production, expansion of agriculture was encouraged on the outer islands, including Sumatra, Kalimantan and Sulawesi. Most of these islands, however, are dominated by acid mineral soils such as Ultisols, Oxisols, and

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Inceptisols covering areas of about 49.8 million ha or 26% of the total land area of Indonesia (Djaenudin and Sudjadi, 1987). Being highly weathered, these soils are infertile, acidic and associate with aluminium toxicity. In addition, these soils have high risk of erosion and degradation. With inadequate fertilizer, these acid soils could make only limited contributions to agricultural production. In Jambi province, acid mineral soils predominant, with a total area of 3.6 million ha or 71% of the total land area of Jambi (Mulyani *et al.,* 1994). Like other acid mineral soils, the main problems of these soils are their low phosphorus and organic matter contents.

Phosphorus (P) is an immobile nutrient and most of P is absorbed by Al and Fe oxides in the soil, thus leaving very small amounts readily available to plants. As a consequence, crop uptake of applied P is very small, at about 10% of the amount applied. Of the fertilizer that is not taken up by plant, only small amounts are lost through leaching or other mechanisms, while the remainder is converted to less available forms in reactions with Al, Fe, and Mn in the soil. The high P requirement of acid mineral soils is a major economic constraint in cultivating these soils. There are four strategies that can be used to overcome this problem: (1) increase phosphorus fertilizer efficiency by optimising the rate and method of application resulting in a substantial residual effect, (2) use cheap P sources, (3) reduce the P sorption capacity of the soil by applying cheap soil amendment, and (4) grow varieties or strains adapted to low soil P status (Sanchez, 1977 in Sudjadi, 1984).

Numerous studies on P and organic matter (OM) management for acid soils have been conducted, however, studies on interactions of P and OM are scarce, especially those using leguminous crop intercropped with the main grain crop. The objectives of this study were to assess crop and soil response to P fertilization, compare inorganic and organic sources of P, and assess the interactions between these sources.

MATERIAL AND METHOD

A field experiment was conducted from the rainy season (AS) 1997/98 until dry season (DS) 1999 on a Typic Dystropept in Pauh Menang village, Pamenang Sub-District, Sarolangun Bangko District, Jambi Province. An incomplete factorial combination of three factors, inorganic phosphorus, organic matter, and lime, were laid out in the field using a randomised complete block design with four replicates (Table 1).

Table 1. P x organic matter x lime treatment combinations of the field experiment at the Pauh Menang village, Jambi Province

Code	Treatment	P rate	Inorganic P		Organic matter		$CaCO_3$
			SP 36	RP	FYM	Stylo	
		kg ha^{-1} crop^{-1}	kg ha^{-1}				
T 1	Control	0	0	0	0	0	3000
T 2	SP 36 (1)	19.1	120	0	0	0	3000
T 3	SP 36 (2)	38.2	240	0	0	0	3000
T 4	SP 36 (3)	57.2	360	0	0	0	3000
T 5	SP 36 (4)	76.3	480	0	0	0	3000
T 6	SP 36 (5)	95.4	600	0	0	0	3000
T 7	SP 36 (2) – lime	38.2	240	0	0	0	0
T 8	FYM	0	0	0	9000	0	3000
T 9	Stylo	0	0	0	0	mulch	3000
T10	RP – lime	42.6	0	300	0	0	0
T11	RP + FYM – lime	56.1	0	300	9000	0	0
T12	RP + Stylo – lime	42.6	0	300	0	mulch	0
T13	SP 36 (2) + FYM	51.7	240	0	9000	0	3000
T14	SP 36 (2) + Stylo	38.2	240	0	0	mulch	3000

Inorganic phosphorus

Six rates (0, 19, 38, 57, 76, and 95 kg P ha^{-1}) of inorganic P in the form of SP-36 were applied in order to study the response of this site to P fertilization. SP-36 is a new form of inorganic P fertilizer that has replaced TSP in Indonesia since 1996. SP-36 has total and 2% citric acid-extractable phosphorus contents of 16.5 and 15.9% P, respectively. In addition to these treatments, and in order to assess alternative and cheaper sources of P fertilizer, rock phosphate (RP) was used directly at rate of 42.6 kg P ha^{-1}. The RP from Christmas Island (CIRP) was fine, with 100% less than 710 μm and 84% less than 180 μm. The total and 2% citric acid-extractable P contents of CIRP was 14.2 and 5.0% P, respectively.

Organic matter

The sources of organic matter were cattle farmyard manure (FYM) and stylo *(Stylosanthes guyanensis* cultivar CIAT 184). FYM at a rate equivalent to 9 t ha^{-1} (field dried weight), was applied 3 tons to one-third of the land area and incorporated along the corn rows. The FYM contained C, N, P, K, Ca, and Mg concentrations of 25.4, 1.79, 0.45, 0.81, 0.57, and 0.24%, respectively. In mid-January 1998, stylo was intercropped between the corn rows in continuous lines. The stylo was pruned periodically and recycled *in situ* as mulch between corn rows, and thus represented recycling, not addition, of nutrients, with the exception of any N fixed by biological nitrogen fixation. The content of nutrients in stylo sampled during the second corn crop were 1.97% N, 0.10% P, 1.66% K, 1.13% Ca, 0.25 % Mg, and 0.21 % S.

Lime

Calcitic lime ($CaCO_3$) was applied to all treatments, except for one SP-36 treatment without lime (T7) and the rock phosphate treatments (T10, T11, and T12). The liming rate was equivalent to 3 t $CaCO_3$ ha^{-1} but only applied 1 ton to one-third of the land area, along corn rows. The amount of lime required was estimated by the titration method, using 0.256 N NaOH, to increase soil pH-H_2O to 5.3.

Each plot received blanket applications of N as Urea, K as KCl, and Mg as Kieserite. All fertilizers were reapplied before planting of the succeeding crop. Corn was planted 3 seeds per hole with spacing of 75 cm x 30 cm in a 6.6 m x 6.0 m plot size. The plant population was reduced to one plant per hill one week after emergence. After harvesting of every crop, composite samples of topsoil were taken from along corn rows to monitor changes in soil characteristics.

RESULTS AND DISCUSSION

The experiment was carried out in four seasons, from rainy season 1997/1998 until dry season 1999. However, the total amount of rainfall in the dry season 1998 was very low and caused failure of the second crop. Consequently, data relating crop response to P fertilization in dry season 1998 was not reliable, and hence hereafter it is not included in the discussion. Concerning rainfall data, it is noteworthy that based on a long-term rainfall record at Bangko, the capital town of Sarolangun Bangko district, about 35 km from Pauh Menang village, the experiment site and its surrounding area has become drier. The mean rainfall in the last 5 years (1995-1999) were lower, and those in the last three years (1997-1999) were much lower, than rainfall in the previous 19 years (1976-1994) (Figure 1).

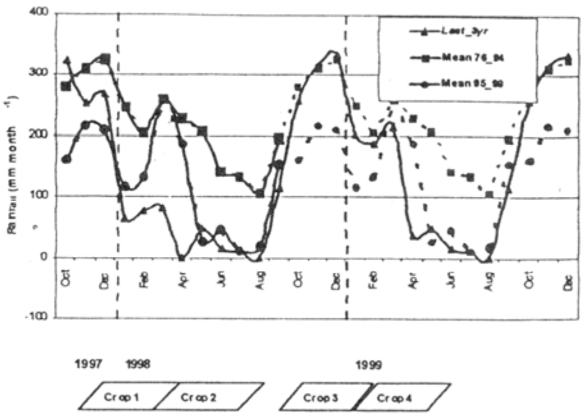


Figure 1. Rainfall distribution in Bangko area, Indonesia

Changes in soil chemical properties

Soil P

Under limed conditions, application of Inorganic P as SP-36 to the first crop considerably increased Colwell P content of the soil. The higher the rate of applied P the higher the increase in soil P (Table 2). The repeated application of inorganic P resulted in large increases in Colwell P content of the soil over time. The SP-36 (2) rate of 38 kg P ha^{-1}crop^{-1} increased soil P content to more than 100 mg P kg^{-1} soil by the third crop, which is far above the critical soil P level. These data suggest that the crop did not take up all of the applied inorganic P and repeated: application of P resulted in accumulation of considerable residual P and built up the P status of the soil. With the unlimed treatment, the application of inorganic P fertilizer as SP-36 (T7) initially resulted in higher Colwell P than that under limed condition (T3), but during crop 3 and 4 the measured soil P was lower. Some of these differences with time and between treatments may be due to problems in obtaining representative soil samples when P and lime were not applied evenly across the whole plot area. Despite this possible problem, the general trends in soil P are as expected from the P applications.

The application of SP-36 in combination with FYM did not produce higher Colwell P contents in the soil compared with application of inorganic P alone. When SP-36 was applied in combination with stylo the Colwell P was lower, presumably as a result of uptake of P by the stylo and/or

Table 2. Effect of P application on Colwell P status of the soil at Pauh Menang village, Jambi, Indonesia

No	Treatment code		P added	Crop 1	Crop 2	Crop 3	Crop 4
			kg P ha^{-1} crop^{-1}	mg P kg^{-1} soil			
T1	Control		0	17	16	38	30
T2	SP 36 (1)		19	22	21	33	27
T3	SP 36 (2)		38	32	31	113	83
T4	SP 36 (3)		57	48	50	138	117
T5	SP 36 (4)		76	57	61	202	111
T6	SP 36 (5)		95	78	90	251	164
T7	SP 36 (2)	- Lime	38	44	30	85	37
T8	Stylo		0	20	18	49	22
T9	FYM		10	18	15	23	17
T10	R P	- Lime	38	23	20	45	46
T11	RP + Stylo	- Lime	38	24	22	34	20
T12	RP + FYM	- Lime	48	25	24	42	24
T13	SP 36 (2) + Stylo		38	48	38	73	55
T14	SP 36 (2) + FYM		48	41	41	128	69

immobilisation by some of the soil organic matter from the stylo. Application of RP at 42.6 kg P ha^{-1} $crop^{-1}$, either alone or in combination with stylo or FYM, resulted in lower Colwell P than the application of SP-36 at the same rate. Analyses of the Colwell P content of the soil when no P fertilizer was added, in the control (T1) and Stylo treatments (T8), revealed that extractable P contents of the soil increased considerably, especially for crops 3 and 4. Increases in available soil P for treatments without applied P may indicate increased cycling of P in readily available organic pools that release inorganic P during the 16 hours Colwell extraction.

Soil pH and cations content

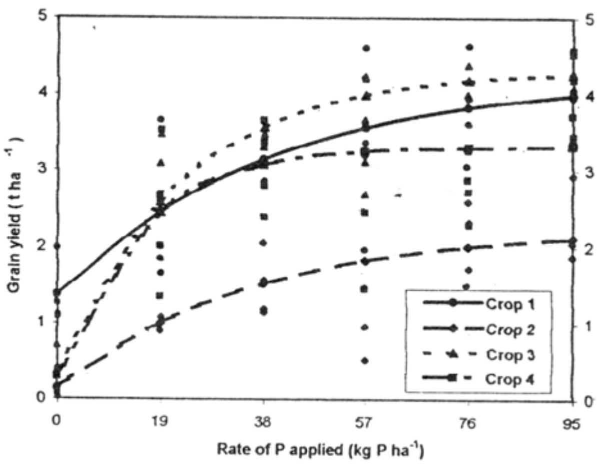
Liming-increased soil pH from 4.6 to 5.3 or higher for topsoils taken at the harvesting time of crop 3 (Table 3). This fulfilled the objective of liming, and as noted, liming resulted in higher Colwell P contents of the soil or increased P availability to crops. Liming with $CaCO_3$ increased Ca, but not Mg and K contents of the soil, and application of FYM increased Mg and K contents of the soil (Table 3).

Responsiveness of the site to P

The response of corn grown at Pauh Menang village to applications of inorganic P as SP-36 (treatments T1 to T6) was assessed by fitting the data to a Mitscherlich equation: Yield = A + B ($e^{(C*P\text{-rate})}$), where Yield is the grain yield and P-rate is the rate of inorganic P applied as SP-36 fertilizer. The curves of the four corn crops (Figure 2) indicate significant increases in grain yield with applied P for all corn crops.

Table 3. Soil pH, Ca, Mg, and K content of top-soils taken after harvest of the 3rd crop

No	Treatment Code	pH-H_2O (1:5)	Ca	Mg	K
			me $100g^{-1}$		
T1	Control	4.6 bcd	3.64 bc	0.31 c	0.25 c
T2	SP 36 (1)	5.4 ab	6.54 ab	0.31 c	0.16 c
T3	SP 36 (2)	5.2 abc	5.90 ab	0.29 c	0.20 c
T4	SP 36 (3)	5.7 a	8.08 a	0.43 bc	0.14 c
T5	SP 36 (4)	5.3 abc	7.20 ab	0.42 bc	0.18 c
T6	SP 36 (5)	5.1 abc	6.29 ab	0.41 bc	0.14 c
T7	SP 36 (2) - Lime	4.3 d	1.09 c	0.23 c	0.17 c
T8	FYM	5.1 abc	5.23 ab	0.60 ab	0.54 a
T9	Stylo	5.5 ab	6.98 ab	0.37 c	0.19 c
T10	R P - Lime	4.2 d	1.19 c	0.31 c	0.38 b
T11	RP + FYM - Lime	4.5 cd	1.56 c	0.66 a	0.44 ab
T12	RP + Stylo - Lime	4.2 d	1.14 c	0.27 c	0.20 c
T13	SP 36 (2) + FYM	5.3 abc	6.55 ab	0.67 a	0.23 c
T14	SP 36 (2) + Stylo	5.5 a	6.28 ab	0.44 bc	0.19 c



Crop 1: Yield = 4.258 – 2.890 (Exp. (-0.025 * P_rate)) $R^2 = 0.96$
Crop 2: Yield = 2.287 – 2.136 (Exp. (-0.027 * P_rate)) $R^2 = 0.89$
Crop 3: Yield = 4.328 – 3.939 (Exp. (-0.043 * P_rate)) $R^2 = 0.98$
Crop 4: Yield = 3.236 – 3.236 (Exp. (-0.065 * P_rate)) $R^2 = 0.94$

Figure 2. Effect of P application as SP-36 (T1-T6) on cron grain yield of crops 1 to 4 at the Pauh Menang site, Indonesia

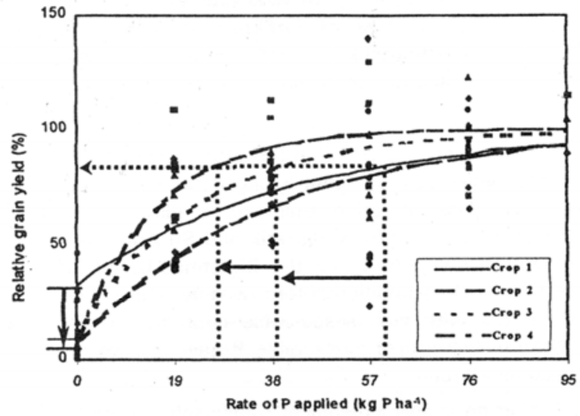


Figure 3. Effect of P application as SP-36 (T1-T6) on relative grain yield of cron crops 1 to 4 at the Pauh Menang site, Indonesia

Comparison of crop responses to P fertilization across cropping seasons could not be done directly using actual yields due to differences in growing conditions of the crops. Therefore, relative yields were, calculated using equation T_i = (Yield T_i) / (Yield Max $_{fitted}$) x 100%, where Yield Max $_{fitted}$ is the value of parameter "A" of the Mitscherlich equation (Figure 3). This presentation indicates the important effect of residual P on crop growth. Taking 85% relative yield as an example, the amount of P fertilizer needed to achieve 85% relative yield decreased from about 62 to 40, and then to 28 kg p ha^{-1} for crop 1 to crop 3, and then to crop 4, respectively. This evidence of the residual effect of P fertilization on crop growth is consistent with the increase in Colwell P with time mentioned above. Another interesting result was the decreasing yield obtained with the control (no added P) treatment from about 35% in crop 1 to less than 10% in crops 3 and 4, suggesting that the P content of the soil declined. However, these results were not substantiated by the data on the Colwell P content of the soil. This may be an analytical problem, an indication that the available P estimates by the Colwell method are not as well correlated to response as other evidence suggests, a partial limitation to growth from other factors than P, or an indication of increased P in the sampled root zone but not the whole soil.

Several studies on P fertilization have been conducted. Wigena *et al.* (1998) reported that application of 20 and 40 kg p ha^{-1} twice a year during three consecutive years incresaed P content of the soil, and the latter rate gave higher values in HCl 25% and Bray 2 extractable P. Didi Ardi *et al.* (1986) working with soybean and Rochayati *et al.* (1986) working with corn found that the optimum P rate for an Ultisol in Rangkas Bitung, West Java, was 40 kg p ha^{-1} with yield level of 2.2 t and 3.6 t ha^{-1} soybean and corn, respectively.

While the primary aim of this experiment was not as an evaluation of soil testing, nevertheless the results are interesting. The relationship between Colwell P content of the soil and corn grain yield showed that the critical P level in the soil was more than 50 mg p kg^{-1} of soil (Figure 4). There were many soil samples with much higher P contents, even more than 200 mg p kg^{-1} soil, but P increase was not accompanied by increasing yields, suggesting that these P contents were well above the critical P level. Furthermore, the

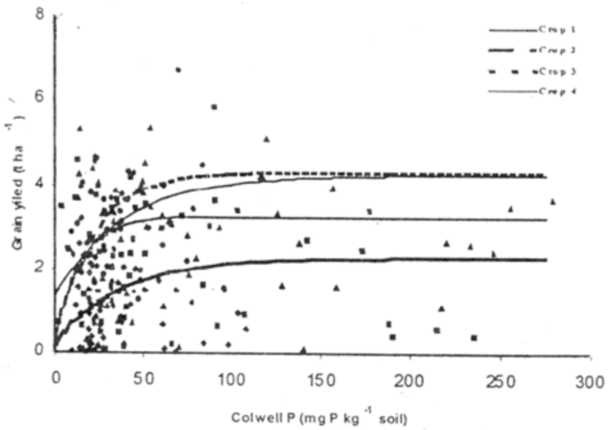


Figure 4. Relationship between Colwell P content of the soil and cron yield at the Pauh Menang site, Indonesia

generally high Colwell P values measured in this study indicates a potential problem with the methodology of soil sampling. It can be argued that the high Colwell P values reflect the status of the banded placement of P fertilizer, not the true P status of the soil, which would explain the rather high critical value. However, as plants can take up P efficiently from concentrated bands of fertilizer, it can be argued that an attempt to evenly sample the whole row plus inter-row areas may underestimate the P supply capacity of the soil.

RAE of different P sources

Relative agronomic effectiveness (RAE) of the different P sources tested in this study were compared with the Mitscherlich fitted values of grain yield obtained in each cropping season with the application of an equivalent amount of P applied as SP-36 (Table 4). This shows that application of organic matter (OM) as FYM or stylo in combination with SP-36 or RP resulted in small increases in corn grain yields and not a synergistic interaction with greater increases in yields, as has been hypothesized.

As a comparison of the different P sources, their effectiveness during the third corn crop are

Table 4. Relative agronomic effectiveness of different P sources compared against the fitted value of grain yield under SP-36 (2) treatment at Pauh Menang village

Code	Treatment	Crop 1	Crop 2	Crop 3	Crop 4
		%			
-	SP-36 (2) fitted	100	100	100	100
T 3	SP-36 (2) observed	115	98	93	106
T 7	SP-36 (2) – lime	70	3	48	30
T 8	FYM	43	-22	32	-16
T 9	Stylo	35	11	23	8
T10	RP	53	20	48	31
T11	RP + FYM	48	27	36	36
T12	RP + Stylo	25	-11	8	4
T13	SP-36 (2) + FYM	99	144	93	112
T14	SP-36 (2) + Stylo	62	43	57	42

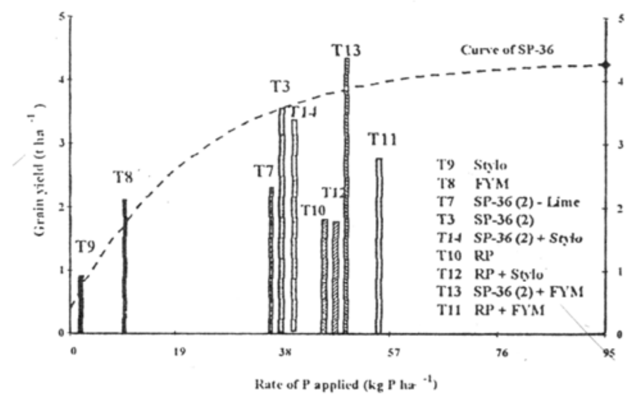


Figure 5. Effect of application of six rates of SP-36 (T1-T6) on grain yield (curve) and effect of sources of fertilizer on grain yield (hystogram) on cron crop 3 at Pauh Menang, Indonesia

presented in Figure 5. At low rates of P application (below 19 kg P ha^{-1}), application of stylo or FYM alone (T9 or 8) produced grain yield similar to those with SP-36. At higher rates, alternative sources, or combined applications of inorganic P and organic matter did not increase grain yield significantly. It is noteworthy that similar results, with no synergistic interactions, were observed in other IBSRAM *ASIALAND* Acid Soils network sites in the Philippines, Vietnam, and Myanmar (Network Report 2000, unpublished). These results differe from those reported by Didi Ardi *et al.* (1986), where application of 4.8 t ha^{-1} OM increased P efficiency from 33.5 to 56.0 kg corn grain per kg P applied. Similarly, a three-year experiment conducted on an Ultisol in Jambi showed that an alley cropping system was a better land management practice to maintain productivity of acid soil, because the system produced additional OM from the pruning of Flemingia hedgerow (Wigena *et al.,* 1998).

The direct use of RP in this study showed that at the similar rate of about 38 kg P ha^{-1} crop^{-1}, the RP was less effective than the readily soluble inorganic SP-36. Wiwik Hartatik and Sri Adiningsih (1987) also reported that the Christmas Island RP with low sesquioxide content was less effective than that with high sesquioxide content, and RP with low citric acid extractable P gave the lowest residual effect.

Liming in this experiment significantly increased and maintained corn grain yields (comparing treatment T3 vs. T7) (Table 4). Liming can increase soil pH, availability of plant nutrients and reduce Al toxicity (Ismunadji, 1984). To reduce Al toxicity to crops, it is not necessary to neutralise all of the exchangeable Al in the soil. The rate of lime to be applied depends on crop to be grown and yield level expected (Sudjadi, 1984). Lime application at a rate of 2 t ha^{-1} to neutralise 0.5 exchangeable Al on an Ultisol in Rangkas Bitung doubled P fertilization efficiency at 40 kg P ha^{-1} from 28.6 to 57.5 kg soybean seed per kg P (Rochayati *et al.,* 1986).

Organic matter management

Organic matter (OM) is a good amendment to improve soil characteristics, not just P status, and usually farmers can obtain some OM on site. However, significant effects of OM generally can be obtained only at considerably higher rates of application than are feasible from on site sources. Better OM management requires the development of cropping systems that can produce a continuous and ample supply of good quality OM at the farm level. In this study, a promising leguminous crop to improve upland acid soils was evaluated. This erect and fast growing stylo, *Stylosanthes guyanensis* cultivar CIAT 184, was tested by planting between rows of corn. During its early stage, the stylo grew quite slowly, but once established it grew very fast. To avoid competition with the main corn crop, it was necessary to prune two to three times during the growing period of the corn crops. In fact, it appears that better timed and more frequent management of the stylo in this experiment may have reduced the competition between the stylo and the corn, and thus makes the stylo/corn combination even more attractive. The biomass produced in each cutting was considerable, especially in plot with P treatments, and ranged from 0.8 to 4.9 t ha^{-1} per cutting (Table 5). The stylo had good nutrient contents, with higher P content on plots with added P (Table 6) .

Table 5. Dry weight of stylo biomass from different cutting times at Pauh Menang site

Treatment	RS 97		DS 98			RS 98			DS 99	
	1	2	3	4	5	6	7	8	9	10
	t ha^{-1}									
Stylo	1.7	2.4	0.8	1.6	2.2	1.5	3.7	3.4	3.1	4.2
SP-36 + Stylo	2.8	5.3	3.7	2.6	2.5	1.4	4.6	4.0	3.6	4.8
RP + Stylo	2.2	3.3	3.9	2.8	2.4	1.1	4.7	4.0	3.7	4.9

Table 6. Nutrient contents of Stylo (2nd cutting) under different P treatments at Pauh Menang village, Jambi, Indonesia

Code	Treatment	N	P	K	Ca	Mg	S
		%					
T9	Stylo	2.2a	0.10b	1.8a	1.1a	0.2a	0.2a
T12	RP + Stylo	2.4a	0.14a	2.2a	0.9a	0.3a	0.2a
T14	Sp-36(2) + Stylo	2.2a	0.14a	1.9a	0.8a	0.3a	0.2a

The introduction of stylo in the cropping system offers a good opportunity to improve soil fertility. The high biomass yield of stylo on the acid mineral soil at the experiment site was encouraging, as the biomass can be fed directly to cattle or sun-dried and ground to be mixed with other materials to enrich feed concentrate that are produced locally in the village, as well as mulched directly on the soil. Widespread adoption of this legume into the cropping systems would enhance cattle rearing in the village, which in turn would produce more FYM as a source of organic P fertilizer and an additional source of income.

CONCLUSION

Under limed conditions, application of inorganic P as SP-36 increased soil P content and repeated application of SP-36 resulted in a build-up in the P status of the soil. Grain yields of corn increased significantly from 0.5 to 3.5 t ha^{-1} with application of SP-36 at about 57 kg P ha^{-1}. The residual effect of P fertilization was shown by the decreasing amount of P fertilizer required to achieve 85% relative yield from about 62 to 40, and then to 28 kg P ha^{-1} for crop 1 to crop 3, and then to crop 4. Rock phosphate used directly, at a rate of 42.6 kg P ha^{-1} was less effective than SP-36 at a rate of 38 kg P ha^{-1}. Liming significantly increased and maintained corn grain yields.

The application of inorganic P as SP-36 in combination with stylo or FYM did not produce higher Colwell P contents in the soil compared with application of SP-36 alone. Application of OM as FYM or stylo in combination with SP-36 or RP did not resulted in synergistic interactions with great increase in yields.

The introduction of the erect and fast growing *Sylosanthes guyanensis* cultivar CIAT 184, in the cropping system offers a good opportunity to improve the fertility of these acid soils. The high biomass yield of stylo, ranging from 0.8 to 4.9 t ha^{-1}, per cutting, can be fed directly to cattle or sun-dried, ground and mixed with other materials to enrich feed concentrate. Widespread adoption of this legume would enhance cattle rearing, which in turn would produce more FYM as a source of organic P fertilizer.

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