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The Effects of Residue Management Practices on Phosphorus and Potassium Uptake in Pineapple

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ABSTRACT

Pineapple residue in Malaysia is usually burnt. The need for sustainable agricultural development coupled with the 1997 haze problem in Southeast Asia has led to the calls for "zero burning". A study was initiated at Simpang Rengam Pineapple Estate, Johor to quantify P and K uptake in pineapple parts and to also compare the efficiency of P and K uptake for burn and no-burn practices. At maturity (sixteen months after planting), three plants were sampled from each treatment and partitioned into roots, stem, leaves, fruit, peduncle and crown, and their dry weight, P and K concentrations determined. Irrespective of treatment difference, P uptake was highest in the fruit, followed by the leaves, stem, crown, peduncle and roots. The order for K was fruit, leaves, stem, peduncle, crown and roots. Between 66 and 58% of the total P and K taken up is recycled and the rest (42 and 34%) is lost through harvest. In situ burning of pineapple leaves before planting does not improve P and K uptake and yield. Major difference in P efficiency for burn (51.60%) and no-burn (53.21%) under fertilized condition was not observed.

Keywords: Nutrient uptake, pineapple residue management, nutrient partitioning, peat, phosphorus, potassium

INTRODUCTION

Pineapple (*Ananas comosus*) is a tropical crop that has distinct parts known as roots, stem, leaves, peduncle, fruit and crown. Except for the fruit, the rest of the crop parts are returned to the soil ecosystem where it becomes one of the sources of the crop's nutrients uptake. In Malaysia, for large-scale pineapple cultivation on peat, the crop residue is recycled through burning before replanting. The benefit of the practice is reduction in cost of production, probably through the avoidance of tillage related problems and practices, and disease and pest control (Jordan 1985).

The 1997 haze problem in Southeast Asia and the need for sustainable agricultural development has led to calls for "zero burning" as an alternative method for crop residue management. However, one aspect that needs to be addressed before final adoption of such a proposal is the quantification of nutrient uptake by pineapple from burn and no-burn practices. It will help

clarify or indicate the nutrient economy; i.e. the amount of nutrients returned to the soil, the quantity retained after cropping and that lost through fruit harvest. The synthesis of this information and that of the economics of burn and no-burn crop management practices may help explain aspects of the viability and the sustainability of the two practices. Apart from this, the study may also, in some way, contribute to the development of a static conceptual model for nutrient uptake and recycling in pineapple. The objective of this study was to quantify P and K uptake in pineapple crop parts and to also compare the efficiency of utilization of added P and K under burn and no-burn conditions.

MATERIALS AND METHODS

The experiment was carried out at Simpang Rengam Pineapple Estate, Johor where pineapple cultivation under burn conditions has been practiced for about 30 years (15 cropping seasons). Gandul, the most commonly used variety was used in the study. Treatments used were: (i) leaf residue removed and no fertilization (LRRNF), (ii) leaf residue burnt (on experimental plots) and no fertilization (LRBNF), (iii) leaf residue removed and fertilization (LRRF) and, (iv) leaf residue burnt (on experimental plots) and fertilization (LRBF). The experimental unit was individual plants planted in 4 m x 12 m plots. In total 300 plants were plantêd in this plot having a randomized complete block design (RCBD) with four replications. Phosphorus and K were applied in the form of China phosphate rock (CPR-14% P) and Muriate of potash (MOP-49.80% K) at the rates (used by the estate) of 35.56 P and 556.56 kg K/ha respectively. The periodic application of the fertilizers after planting were as follows:

Fertilizer nutrient	Number of days after planting				
	83	144	209	263	Total
	kg/ha				
P	10.67	10.67	7.11	7.11	35.56
K	88.54	88.54	189.74	189.74	556.56

At maturity (sixteen months after planting), three plants from each treatment were randomly sampled and partitioned into roots, stem, leaves, peduncle, fruit and crown. These parts were oven dried at 60°C until constant weight was attained and their dry weight taken. Dead leaves (slashed from old stands and raked) were collected before the start of the experiment from four of the experimental plots (one from each of the four replications) intended to be assigned the burn treatment. The leaves were air-dried and after obtaining constant weight, they were burnt and the weight of the ash

recorded. A direct proportional relationship was assumed for estimating the amount of ash added through in situ burning on a per hectare basis. Dry ashing method (single dry ashing) was used for the extraction of P and K in crop parts and ash. Molybdate blue method (Murphy and Riley 1962) was used for P determination. Potassium was determined using atomic absorption spectrophotometer. Phosphorus and K uptake were determined by multiplying the dry weight of crop parts by their respective concentrations. The product of P and K uptake per crop and plant density of 62,500 gave the total P and K uptake/ha in the distinct parts. The amount of ash per hectare multiplied by the P and K concentrations represented the approximate amounts of P and K recycled through burning. Nutrient efficiency was calculated according to the general formula of Pomares-Gracia and Pratt (1978):

$$\% \text{ fertilizer nutrient recovery} = \frac{(TNF) - (TNU)}{R} \times 100$$

where

TNF = total nutrient uptake from fertilized plots
TNU = total nutrient uptake from unfertilized plots
R = rate of fertilizer nutrient applied

Soil samples were taken at the depths of 0-5, 5-25 and 25 cm before the start of the experiment. Extractable P and K in the soil were extracted using the double acid method (0.05 M HCl: 0.025 M H2SO4) with soil to solution ratio of 1:10 (modified from Van Lierop et al. 1980). Reasons behind the modification of the extraction method were: (i) A dilute soil extractant helps in eliminating the possibility of the neutralization of the extracting solution through reaction with the soil and possibly reaction of Ca and Mg existing in the burnt crop residue plus artifacts in the soil, and (ii) Prolonged extraction time plus wider extraction ratio helps in minimizing the effects of rewetting time variability of dry peat (Van Lierop et al. 1980). Phosphorus and K were determined using the aforementioned methods above.

RESULTS

The initial status of extractable P and K of the peat soil at the depths of 0-5, 5-25 and 25 cm were relatively high (Table 1). Dry matter yield (whole plant) for the treatments (LRRNF, LRBNF, LRRF and LRBF) in ascending order were 18.14, 20.52, 27.94 and 28.53 Mg/ha (Table 2). In terms of parts the dry matter production (ascending order) regardless of treatments were roots, peduncle, crown, stem, fruit and leaves (Table 2). Generally, P and K concentrations were relatively similar for all the treatments (Table 2). The total uptake of P (kg/ha) for the LRRNF, LRBN, LRRF, and LRBF treatments

TABLE 1
The initial status of extractable P and K at three different soil depths

Depth (cm)	P	SEM*	K	SEM*
	— mg/kg —		— mg/kg —	
0 – 5	54.33	5.42	492.63	39.39
5 – 25	18.28	1.20	434.04	44.25
> 25	19.23	1.73	432.21	42.96

* SEM – Standard error of the mean

ranged from 23.10 through 26.57 to 42.02 and 44.92 kg/ha; with the highest being observed when fertilizers were applied (both leaf residue removed or burnt). Uptake of K ranged from 360.07 through 373.76 to 526.55 and 574.62 kg/ha and again the higher values were obtained in the plots where fertilizers were applied. Irrespective of treatment difference, K uptake was highest in the fruit, followed by the leaves, stem, peduncle, crown and roots. The order for P distribution was a reduction from that in fruit, leaves, stem, crown, peduncle and roots respectively (Table 3). The results of the comparisons of treatment means (Tables 3 and 4) were: (i) LRRNF and LRBNF – significant increase in K uptake in roots only and no significant increase in yield (fresh fruits), and (ii) LRRNF and LRRF – significant increase in P uptake in fruit, stem, and leaves. In the case of K a significant increase in uptake occurred in roots, fruit, stem and leaves and yield. (iii) LRBNF and LRBF – significant increase in P and K uptake in roots, fruit, stem and leaves and yield. (iv) LRRF and LRBF – significant increase in P and K uptake in roots only with no significant increase in yield. Phosphorus and K addition through burning leaf residue (1.31 Mg/ha ash) were estimated at 18.69 and 240.43 kg/ha respectively. Phosphorus and K from CPR and MOP applied under LRRF and LRBF amounted to 35.56 and 556.56 kg/ha (Table 4).

Out of the 18.69 and 240.43 kg/ha of P and K recycled respectively through burning, 18.57 and 5.69% P and K were respectively utilized under LRBNF. In the case of LRBF, 40.32 and 26.92% P and K were utilized upon the application of 54.25 kg/ha P (ash and fertilizer) and 796.99 kg/ha K (ash and fertilizer). In terms of fertilizer only, while P efficiency under the LRBF and LRRF treatments were 51.60 and 53.21% respectively upon the application of 35.56 kg/ha P, that of K at rate of 556.56 kg/ha were estimated at 36.09 and 29.91%.

DISCUSSION

Between 66 and 58% of P and K respectively in pineapple goes back to the soil. The rest (42 and 34%) is principally lost through fruit harvest. Despite this high value, it is important to note that not all P and K recycled may be

TABLE 2
Dry weight (DW) and P and K concentrations in pineapple parts

Parts	LRRNF			LRBNF			LRRF			LRBF		
	DW	P	K	DW	P	K	DW	P	K	DW	P	K
	Mg/ha	%		Mg/ha	%		Mg/ha	%		Mg/ha	%	
Roots	0.35	0.02	0.09	0.42	0.02	0.09	0.45	0.02	0.08	0.55	0.20	0.08
Peduncle	0.64	0.70	3.69	0.68	0.07	3.34	0.69	0.09	3.41	0.74	0.08	3.19
Crown	0.92	0.14	1.41	1.00	0.14	1.23	0.82	0.17	1.42	0.81	0.15	1.41
Stem	3.54	0.27	4.20	4.20	0.24	3.72	5.59	0.26	3.56	5.27	0.29	4.18
Leaves	3.94	0.12	2.03	4.34	0.13	1.92	7.14	0.17	2.03	7.38	0.17	2.08
Fruit	8.75	0.08	1.08	9.88	0.09	1.00	13.25	0.10	1.11	13.78	0.11	1.20
Total	18.14	-	-	20.52	-	-	27.94	-	-	28.53	-	-

TABLE 3
Comparison of the treatment means of the P and K uptake in pineapple parts under burn and no-burn (with and without fertilizer) conditions

Treatment	P	K
	kg/ha	
(a) Roots		
LRRNF	0.07[a]	0.32[a]
LRBNF	0.08[a]	0.38[b]
LRRF	0.09[a]	0.36[b]
LRBF	0.11[b]	0.44[c]
(b) Peduncle		
LRRNF	0.45[a]	23.62[a]
LRBNF	0.48[a]	22.71[a]
LRRF	0.62[a]	23.53[a]
LRBF	0.60[a]	23.61[a]
(c) Crown		
LRRNF	1.29[a]	12.97[a]
LRBNF	1.40[a]	12.30[a]
LRRF	1.39[a]	11.64[a]
LRBF	1.22[a]	11.42[a]
(d) Fruit		
LRRNF	9.56[a]	148.68[a]
LRBNF	10.08[a]	156.24[a]
LRRF	14.53[b]	199.00[b]
LRBF	15.28[b]	220.29[b]
(e) Stem		
LRRNF	4.73[a]	79.98[a]
LRBNF	5.64[a]	83.33[a]
LRRF	12.14[b]	144.94[b]
LRBF	12.55[b]	153.50[b]
(f) Leaves		
LRRNF	7.00[a]	94.50[a]
LRBNF	8.89[a]	98.80[a]
LRRF	13.25[b]	147.08[b]
LRBF	15.16[b]	165.36[b]

Note: Same letter within a column indicates insignificant differences between treatment means using LSD $P \leq 0.05$.

TABLE 4
Comparison of the treatment means of burn and no-burn practices with and without fertilizer on pineapple yield

	LRRNF	LRBNF	LRRF	LRBF
	Mg/ha			
Yield	46.27[a]	49.43[a]	56.25[b]	56.81[b]
Standard error	1.29	0.46	1.19	1.47

Note: Same letter denotes insignificant difference at $P \leq 0.05$ using LSD.

utilized by the crop. The crop may use only a certain amount of what is returned. The reason being that the proportion of nutrients utilized may depend on factors like soil type, rainfall (Funakawa *et al.* 1996), type of crop and the form in which dry matter is recycled through burning, mulching or incorporated in the soil (Ball-Coelho *et al.* 1993). Apart from roots, burning did not significantly increase P and K uptake (Table 3) and yield (Table 4). This may be attributed to low recovery of nutrients since besides early application (before planting) as compared to fertilizer application (3 months after planting), P and K uptake in pineapple is generally slow during the early growth period (Py *et al.* 1987). Thus due to high moisture saturation and subsequent drainage following heavy rainfall, loss of nutrients and through surface runoff. Leachingeffects (Funakawa et al. 1996) is also a possible reason.

Unlike in organic soils under sugarcane cultivation where P and K fertilizers contribute very little (Coale *et al.* 1993), the contribution of P and K fertilizer to the total soil pool of peat under pineapple plantation is substantial. This means that peat has a low capacity to supply P and K (Funakawa et al. 1996), and that nutrients should be added regularly to compensate for the loss of nutrients through crop uptake.

It has been shown that P utilization in the organic soils is relatively higher than that of mineral soils (Zaharah *et al.* 1997; van Reuler and Janssen1996; Zaharah *et al.* 1989;). Earlier work has shown that the addition of 100 kg P/ ha of CPR, results in P utilization under corn cultivation of 24%. This value is half of that (53.21%) recorded for the no-burn treatment (LRRF) when 35.56 kg P/ha in the form of CRP was applied. Aside from low sorption of P in organic soils (Cogger and Duxbury 1984), low pH of peat may also account for the difference. The low pH of peat may have facilitated P release from phosphate rock dissolution (Wright *et al.* 1992) and because of low P sorption capacity in peat, P is readily available for plant uptake. Different crops take up different amounts of nutrients. Fruits, in general, utilize P more efficiently than cereals (Chien *et al.* 1990).

CONCLUSION

In situ burning of pineapple leaf residue before planting does not improve both P and K uptake as well as yield. In terms of efficiency, about 51.60 and 36.09% of the total P and K (35.56 and 556.56 kg/ha) were, respectively utilized under the burn condition (fertilized). In the case of the no-burn condition (fertilized), about 53.21 and 29.91% of the total P and K (35.56 and 556.56 kg/ha) were respectively used.

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