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Macronutrients Distribution and Cycling of Pineapple Planted on Tropical Peat

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ABSTRAK

Kajian ini mengkuantitikan kemasukan, kehilangan, penahanan (tanah) dan pengambilan serta pengembalian P, K, Ca, dan Mg untuk pengurusan sisa nenas yang dibakar dan tidak dibakar. Rawatan yang digunakan adalah: sisa daun dikeluarkan dan tiada pembajaan (LRRNF), sisa daun dibakar dengan tiada pembajaan (LRBNF), sisa daun dikeluarkan dan diikut pembajaan (LRRF) dan sisa daun dibakar dan pembajaan dilakukan (LRBF). Nitrogen, P dan K dibekalkan dalam bentuk urea (46.00% N), batuan fosfat China (CPR 14.00% P) dan muriate of potash (MOP 49.80% K) pada kadar 701.04, 35.56 dan 556.56 kg N, P dan K per hektar mengikut turutan. Simulator hujan digunakan untuk menghitung larian permukaan pada plot sisa dibakar sebelum penanaman. Sampel tanah pula diambil pada kedalaman 0-5, 5-25 dan . 25 sm sebelum, semasa dan selepas peringkat-peringkat pembajaan. P, K, Ca dan Mg yang tersedia diestrak menggunakan kaedah dwiasid. Kaedah subtraksi pula digunakan untuk menganggar P, K, Ca dan Mg yang dilarut lesap (kg per ha). Pada peringkat matang, sampel tumbuhan diambil pada setiap rawatan dan dibahagikan kepada akar, batang, daun, buah, jambul dan tangkai serta berat kering dan kandungan P, K, Ca dan Mg di tentukan. Kandungan P, K, Ca dan Mg pada tanah, bahagian tumbuhan dan air hujan ditentukan melalui kaedah 'molybdate blue' dan spektrofotometer penyerapan atom (AAS). Penambahan P, K, Ca dan Mg daripada baja, abu dan presipitasi bagi LRBF dianggarkan pada 54.25, 816.68, 103.31 dan 23.54 kg per ha. Rawatan LRRF (pembajaan dan presipitasi) pula dianggarkan pada 35.56 P, 576.05 K, 100.17 Ca dan 4.93 Mg kg per ha. Anggaran kehilangan P, K, Ca dan Mg pada rawatan LRBF adalah pada 18.44, 300.45, 66.06 dan 8.63 kg per ha manakala pada rawatan LRRF, nilai-nilai adalah pada 23.19, 244.88, 45.79 dan 5.49 kg per ha. Larut lesap merupakan punca utama kehilangan P, K, Ca dan Mg bagi kedua-dua jenis pengurusan dan ini dapat dirujukkan dengan frekuensi pembajaan yang kurang sesuai. Satu keseimbangan positif P, K, Ca dan Mg dapat direkodkan untuk LRBF, 46.00% P, 28.005 K, 20.00% Ca dan 27.00% Mg dapat dikitarsemula selepas penanaman. Bagi rawatan LRRF pula, keseimbangan positif P, K, Ca dan Mg diperhatikan. Lebih kurang 60.00% P, 20.00% K, 13.00% Ca dan 36.47% Mg digunasemula untuk rawatan ini.

ABSTRACT

This research quantifies P, K, Ca and Mg inputs, losses, retention in soil, and uptake and returns for burnt and unburnt pineapple residue in management practices. Treatments used were: leaves residue removed and no fertilization (LRRNF), leaves residue burnt and no fertilization (LRBNF), leaves residue removed and fertilization (LRRF), and leaves residue burnt and fertilization (the usual practice) (LRBF). Nitrogen, P and K were applied in the forms of urea (46.00% N), China phosphate rock (CPR 14.00% P) and muriate of potash (MOP 49.80% K) at the rates of 701.04, 35.56, and 556.56 kg N, K, and P per ha respectively. Rainfall simulator was used for surface runoff measurement on burnt plots before planting. Soil sampling at the depths of 0-5, 5-25 and . 25 cm were done before planting, during and after fertilization stages. Extractable P, K, Ca and Mg were extracted using the double-acid method. The subtraction method was used to estimate P, K, Ca and Mg leached (kg per ha). At maturity, plants were sampled from each treatment and partitioned into roots, stem, leaves, fruit, crown and peduncle, and the dry weights, of P, K, Ca and Mg contents determined. Molybdate blue method and atomic absorption spectrophotometer were used in determining P, K, Ca and Mg in soil, plant parts and *rainwater, K, Ca and Mg additions from fertilizer, ash and precipitation for LRBF were estimated at 54.25, 816.68, 103.31 and 23.54 kg per ha, and those of LRRF (fertilizer and precipitation) were 35.56, 576.05, 100.17, and 4.93 kg P, K, Ca, and Mg per ha, respectively. The estimated amounts of P, K, Ca and Mg lost under LRBF were 18.44, 300.45, 66.06 and 8.63 kg per ha and in the case of LRRF, the losses were 23.19, 244.88, 45.79 and 5.49 kg per ha. Leaching was the major source of P, K, Ca and Mg loss for both practices and this was attributed to inappropriate fertilization frequency. A positive balance of P, K, Ca and Mg was recorded for LRBF, 46.00% P, 28.00% K, 20.00% Ca and 27.00% Mg which could be recycled after cropping. In the case of LRRF, a positive balance of P, K and Ca was observed. About 60.00% P, 20.00% K, 13.00% Ca and 36.47% Mg get recycled for LRRF.*

INTRODUCTION

Cultivation of pineapple (*Ananas comosus*) on peat in Malaysia has been in existence for about a century (Selamat and Ramlah 1993). The cultivation currently practiced on large-scale initially started on small-scale basis with no fertilization. After the extensive and comprehensive survey of the pineapple cultivation (Dunsmore 1957), the need to apply balanced fertilizers for the growth and production of pineapple surfaced. Consequently, various fertilizer recommendations (Tay 1972; Tay 1973) for varieties like Singapore Spanish, Masmerah and Johorel were put forward. The recommendations were nutrient response oriented and as such none of the studies attempted or gave due cognizance of nutrient losses through leaching and runoff, nutrient retention after cropping not to mention inputs from ash and precipitation.

Perhaps when it became obvious that the previous recommendations have outlived their usefulness, a study was initiated to determine the right requirement of N, P, and K of these varieties on peat (Selamat and Ramlah 1993). Again, physical and physiological parameters were the focus of the study. Even though the study was conducted at a time when nutrients addition through burning crop residue, precipitation, leaching, and surface runoff losses and the mechanism of nutrient retention in organic soils had advanced, a holistic approach like nutrient balance was not considered.

With the ever increasing cost of fertilizers, plus the ever increasing awareness of the polluting effects that excess fertilizer applications have on the environment, there is a need to quantify the movement of nutrients into, within and without pineapple cultivation system. A broad based approach of this kind referred to as nutrient budget can be used as a tool in estimating the nutrient requirements of pineapple and hence help in the reduction of polluting effects that excess fertilizer applications may have on the environment. The study was conducted to quantify P, K, Ca and Mg inputs, losses, retention (soil), and returns for burnt and unburnt pineapple residue management practice.

MATERIALS AND METHODS

The experiment was carried out at Simpang Rengam Pineapple Estate, Johor, Malaysia. This place is a representative area for pineapple cultivation on peat in Malaysia. Treatments used were: (i) leaves residue removed and no fertilization (LRRNF), (ii) leaves residue burnt and no fertilization (LRBNF), (iii) leaves residue removed and fertilization (LRRF) and, (iv) leaves residue burnt and fertilization (the usual practice) (LRBF). The experimental unit was individual plants planted in 4 m x 12 m plot. Altogether 300 pineapple plants were planted in each plot having a randomized complete block design (RCBD) with 4 replications. The 1997 haze incident in South-East Asia has drawn public attention and concern to the polluting effect of open burning of crop residue on the environment, hence the inclusion of treatments i and iii.

Nitrogen, P and K were applied in the forms of urea (46.00% N) China phosphate rock (CPR-14.00% P) and muriate of potash (MOP-49.80% K) at the rates of 701.04, 35.56, and 556.56 kg of N, K, and P per ha, respectively. These rates are the rates used by the pineapple estate.

Prior to the start of the experiment, infiltration rate was measured in all the burnt plots using the double ring infiltrometer. Before first fertilization, water samples from surface runoff on the burnt plots using rainfall simulator (Kamphorst 1987) were collected, filtered and analyzed for P, K, Ca and Mg. Throughout the study, P was analyzed using molybdate blue method (Murphy and Riley 1962) and K, Ca, and Mg were analyzed using the atomic absorption spectrophotometer.

K, Ca, and Mg concentrations were multiplied by volume of runoff collected within 3 minutes per 0.0625 m^2 (area covered by the base of the rainfall simulator). Simple proportion was then used to convert the values to kg per ha basis. Kilogram per ha P, K, Ca and Mg multiplied by the number of runoff days gave the total amounts of P, K, Ca and Mg (kg per ha) lost through surface runoff between the period at which the experiment was started and the first fertilizer application. Surface runoff days refer to the rainy days on which runoff occurred and these days were selected based on the assumption that surface runoff occurs when rainfall intensity is higher than infiltration rate (Jackson 1989).

Peat core samplers of diameter 7.50 cm were used to collect peat samples at the depths of 0-5, 5-25 and .25 cm for bulk density determination. These sampling depths were also used to monitor leaching loss. Soil samples were taken before planting, fertilization and after fertilization stages. At the fertilization phase, samples were taken 3 weeks after fertilization so as to ensure uniform distribution and dissolution of the fertilizers. Subsequent post fertilization samples were taken bimonthly until the end of the experiment. Rainwater was collected from three rain gauges located at three different places in the estate at every sampling period stated and analyzed for P, K, Ca, and Mg.

Some plants of the different treatments were randomly selected and tagged when visual differences between the treatments began showing at the third month. Nutrients accumulation in leaves with time was monitored right from the third month of planting until plants were harvested by taking D-leaf and the contents of P, K, Ca, and Mg determined. D-leaf is the longest and easily identifiable leaf that provides a reliable and sensitive indication of pineapple nutritional status (Py *et al.* 1987). At maturity, 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 and their dry weights taken. Dry ashing (single dry ashing) was adopted for the extraction of P, K, Ca, and Mg., K, Ca, and Mg distribution were determined by multiplying the weight of plant parts by their respective concentrations. The products of P, K, Ca and Mg distribution per plant and plant density gave the total P, K, Ca, and Mg kg per ha in the distinct parts of the pineapple.

K, Ca, and Mg in soil were extracted using the double acid method (0.05*M* HCl: 0.025*M* H_2SO_4) with soil to solution ratio of 1:10 (modified from Van Lierop *et al.* 1980). The reason 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 coming from 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).

Weight of soil per ha at .25 cm (i.e. approximately 25-50 cm) multiplied by the respective concentrations of P, K, Ca and Mg gave the total amounts of kg P, K, Ca, and Mg per ha at that depth (leaching zone). Weight of soil per ha was estimated by multiplying a hectare volume of soil at .25 cm with the corresponding bulk density. The amounts of P, K, Ca, and Mg leached per ha at each sampling period were calculated using the subtraction method shown: TNL = NAF - NAU; where TNL = Total nutrient leached, NAF = Nutrient accumulated at .25 cm in fertilized plots, and NAU = Nutrient accumulated at .25cm in unfertilized plots (modified after Pomares-Gracia and Pratt 1978). For the burnt practice, leaching loss at sampling periods started from the first sampling after burning until the end of the cropping period and that of the unburnt started from the first sampling after first fertilization till the end of the cropping period. The depth of .25 cm was chosen as leaching zone because it was assumed that nutrients at this zone are beyond the reach of pineapple roots as roots grow laterally (Py *et al.* 1987).

RESULTS AND DISCUSSION

General Information

The bulk density at the depths of 0-5, 5-25, and .25 cm were 0.16, 0.23 and 0.13 g per cm^3 respectively. The infiltration rate of 0.2 cm per minute was obtained. The initial status of the extractable P, K, Ca, and Mg were relatively high (Table 1). Since the land has been under cultivation for the past 30 years, there is the tendency that residual accumulation might have taken place. Insignificant difference in P, K, Ca, and Mg contents in the soil were observed for the plots assigned the intended treatments:

LRRNF, LRBNF, LRRF and, LRBF before the start of the experiment (Table 1).

The general accumulation of the extractable P, K, Ca, and Mg for LRRF and LRBF at 0-5 cm (Table 2) may be due to inappropriate fertilizer application frequency. Besides the less mobile nature of P, the high accumulation of Ca might have also contributed to the P accumulation at 0-5cm (Cogger and Duxbury 1984).

Nutrients Addition

The sources of P, K, Ca, and Mg additions were fertilizer, ash, and precipitation with fertilizer contributing the highest amounts of P, K, and Ca for LRBF and LRRF (Table 3). For LRBF, ash contributed the highest amount of Mg with its P and K contribution second to fertilizer. The Ca from ash was relatively low as compared to those of fertilizer and precipitation (Table 3). Precipitation contributed no P, however, its contribution of K, Ca, and Mg was relatively high (Table 3) compared to the findings of Mohammad (1981) and Veneklass (1990). Possibly, the distance of the experimental site from the sea (about 20 km), the haze problem (during the experiment) in South-East Asia and the possibility of some ash suspension during and after burning may account for the difference. The total amounts of P, K, Ca, and Mg from fertilizer, ash, and precipitation addition to the pineapple nutrient cycle were 54.25, 816.48, 103.31 and 23.54 kg per ha for LRBF and 35.56, 576.05 100.17 and 4.93 kg per ha for LRRF (Table 3).

Nutrient Losses

Leaching was the major source of P, K, Ca, and Mg loss under LRBF and LRRF. In the case of LRBF, second to leaching loss was through fruit harvest (Table 3). Apart from Mg where the loss through fruit harvest was third to leaching, P, K, and Ca loss through residue removal was second to leaching followed by fruit harvest. Phosphorus, Ca, and Mg loss through surface runoff was relatively low. The total amounts of P, K, Ca, and Mg lost under LRBF were 18.44, 300.45, 66.06 and 8.63 kg per ha and those of LRRF were 23.19, 244.88, 45.79 and 5.49 kg per ha (Table 3).

Except for Mg where leaching occurred after fertilization, leaching loss of P, K, and Ca occurred before, during and after fertilization. Generally, the bulk of K, Ca, and Mg got leached at the post fertilization stage. The reason being that, more of P, K, Ca, and Mg got accumulated at the fertilization phase especially during the last fertilization (263[rd] day after planting) – a period where the plants were nine months old. At that stage, nutrient requirement of pineapple is generally lower than during or early growth

TABLE 1
The initial status of extractable P, K, Ca and Mg at three different depths before experimentation

Treatments	Depth (cm)	P	K	Ca	Mg
			mg/kg		
LRRNF	0 – 5	48	540	1397	90
	5 – 25	20	446	835	60
	. 25	20	383	940	85
LRBNF	0 – 5	40	503	1418	88
	5 – 25	20	400	920	60
	. 25	20	382	865	58
LRRF	0 – 5	53	472	1347	83
	5 – 25	20	460	800	58
	. 25	25	423	850	63
LRBF	0 – 5	43	535	1370	107
	5 – 25	20	520	775	70
	. 25	20	427	928	73

Note: Insignificant difference between treatments at same depths using LSD ≤ 0.05 was observed.

TABLE 2
Extractable P, K, Ca and Mg at various sampling stages

Sampling days	Extractable nutrients															
	P				K				Ca				Mg			
	LRNF	LRBNF	LRRF	LRBF	LRNF	LRBNF	LRRF	LRBF	LRBF	LRBNF	LRRF	LRBF	LRBF	LRBNF	LRRF	LRBF
	kg ha-I															
48	88	115	113	200.00	555	1395	563	1758	2718	4163	2198	4446	195	383	183	348
144	40	48	110	193	520	448	885	1040	1628	1865	2130	2143	130	198	180	220
263	53	45	2700	2733	320	373	3300	3093	1945	2265	7175	7843	253	283	635	655
365	33	33	1450	1207	135	182	574	443	1222	2205	4810	4873	78	235	233	181
417	18	13	1145	590	260	228	265	368	1105	1925	4838	4528	78	175	120	123
466	23	25	793	500	245	266	290	270	1127	1900	1970	3536	77	93	95	95

TABLE 3
P, K, Ca and Mg inputs, losses, returns and retention (soil) for burnt and unburnt practices

	LRBF (leaves burnt)				LRRF (leaves removed)			
	P	K	Ca	Mg	P	K	Ca	Mg
				kg/ha				
Inputs								
Fertilizer	35.56	557.09	62.48	0.41	35.56	557.09	62.48	0.41
Ash	18.69	240.43	3.14	18.60	0.00	0.00	0.00	0.00
Precipitation	0.00	18.96	37.69	4.53	0.00	18.96	37.69	4.53
Total (a)	54.25	816.48	103.31	23.54	35.56	576.05	100.17	4.93
Losses (b)								
Fruit	5.72	71.61	2.26	2.03	4.97	50.32	2.61	1.62
Leaves residue	0.00	0.00	0.00	0.00	6.52	51.16	2.66	1.27
Leaching	11.57	183.69	59.15	5.20	11.70	143.40	40.52	2.60
Runoff (ash)	1.15	45.15	4.65	1.40	0.00	0.00	0.00	0.00
Total (b)	18.44	300.45	66.06	8.63	23.19	244.88	45.79	5.49
Input-Loss (c)	35.81	516.03	37.25	14.91	12.37	331.17	54.38	-0.56
Uptake (d)	16.10	142.94	7.39	3.96	7.43	65.00	6.14	2.83
Amount Retained in soil = c − d	19.71	373.09	29.86	10.95	4.94	266.17	48.24	-3.39

stage (Py et al. 1987) therefore, with annual rainfall of about 1917 mm coupled with the very low clay (Stevenson 1994), the potential for P, K, Ca, and Mg lost through leaching was high.

Nutrients Removal and Returns

Under LRBF, the total amounts of P, K, Ca, and Mg taken up (roots, stem, leaves, peduncle and crown) from fertilizer, ash and precipitation that can be recycled were 16.10, 142.94, 7.39, and 3.96 kg per ha. Those of LRRF (roots and stem) were 7.43, 65.00, 6.14, and 2.83 (Table 3). It must be noted that, since leaves, peduncle and crown for LRRF are not recycled, their nutrients removal was considered loss and were excluded in this section.

Nutrients Retention after Cropping

After taking into account nutrients returns and losses, the amounts (kg per ha) of P, K, Ca, and Mg from inputs (fertilizer, ash, and precipitation retained) in the soil (at 0-5 and 5-25cm) after cropping were 19.71, 373.09, 29.86 and 10.95 for LRBF and 4.94, 266.17, 48.24 and 2.27 kg per ha for LRRF (Table 3).

Unutilized P, K, Ca, and Mg under LRBF were relatively high. K and Ca retained under LRRF were also high but with low P. This low P may partly be due to residue removal as it contributed about 28% (second to leaching loss) of the total P lost. It is therefore anticipated that if this practice goes on for some time, more P will be depleted and hence rescheduling of fertilizer program will be inevitable. The negative balance of Mg (Table 3) recorded for LRRF may be attributed to the unaccountability of Mg addition through stem and roots decomposition during the cropping period as these parts under LRRF are normally not removed from the field. However, for the sake of accountability if it is considered or assumed that the amount of Mg taken from the inputs (fertilizer and rainfall) by these parts is proportional to the amount returned through decomposition, about 2.83 kg Mg per ha is recycled and hence the 2.83 kg Mg per ha balances the deficit.

CONCLUSIONS

The existing fertilization regime particularly for K in pineapple cultivation on peat for the burnt and unburnt pineapple residue management practices is inappropriate. There is therefore the need to reschedule the present fertilizer regime. Perhaps the last fertilization needs to be stopped.

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