

Some Observations in Pineapple Production under Different Fertilizer Programmes and Different Pineapple Residue Management Practices

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ABSTRAK

Kajian ini dijalankan untuk mengubah suai program pembajaan yang sedia ada, mengenal pasti program pembajaan bersama amalan pengurusan sisa nenas yang berkesan dari segi ekonomi. Program pembajaan yang digunakan ialah (i) pembajaan N (176, 176, 176 dan 176 kg ha⁻¹), P (11, 11, 7 dan 7 kg ha⁻¹), K(89, 89, 188, dan 188 kg ha⁻¹) pada hari 65, 135, 191 dan 233 masing-masing selepas penanaman (amalan biasa) (FP1); (ii) pembajaan N (176, 176, dan 176 kg ha⁻¹), P (11, 11, dan 7 kg ha⁻¹), K(89, 89, dan 188 kg ha⁻¹) pada hari 65, 135 dan 191 hari masing-masing selepas penanaman (FP2) dan, pembajaan N (176, 264, dan 264 kg ha⁻¹), P (11, 14, dan 11 kg ha⁻¹), K(89, 183, dan 285 kg ha⁻¹) pada hari 65, 135, dan 191 masing-masing selepas penanaman (FP3). Pengurusan sisa yang digunakan ialah (i) pereputan sisa nenas secara in situ tanpa gangguan (RM1); (ii) penimbunan sisa nenas (daun, jambul, dan "peduncles") yang dipotong dan dikaruk dari baris 0.6 m x 10 m ke 0.9 m x 10 m (teknik "zero burning" -RM2), dan pembakaran daun, jambul, dan "peduncles" nenas secara in situ iaitu amalan biasa (RM3). Kombinasi rawatan program pembajaan serta pengurusan sisa nenas adalah seperti berikut: RM1FP1, RM1FP2, RM1FP3, RM2FP1, RM2FP2, RM2FP3, RM3FP1, RM3FP2 dan RM3FP3. Analisa statistik menunjukkan tiada perbezaan di antara ketiga-tiga program pembajaan (FP1, FP2, FP3) mahupun pengurusan sisa nenas (RM1, RM2, RM3) yang dapat meningkatkan hasil buah nenas secara bererti. Dari segi kos, FP2 merupakan program pembajaan yang paling murah, diikuti oleh FP3 dan FP1. RM1 pula merupakan amalan pengurusan sisa nenas yang paling murah, diikuti oleh RM2, dan RM3. Secara keseluruhan, kombinasi rawatan RM1FP2 merupakan program pembajaan dan pengurusan sisa nenas yang paling ekonomi. RM1 merupakan amalan yang paling ekonomi untuk nenas yang ditanam atas peat tropika walaupun ketiga-tiga teknik "zero burning" (RM2), pereputan sisa nenas secara in situ tanpa gangguan (RM1) dan pembakaran sisa nenas secara in situ tidak meningkatkan hasil nenas secara bererti. Pembajaan N, P, dan K pada hari 65, 135, dan 191 hari selepas penanaman (FP2) merupakan amalan pengurusan baja yang paling ekonomi, program ini dapat menjimatkan USD 110.17 ha⁻¹. Oleh itu, FP2 merupakan program pembajaan yang paling ekonomi bersama-sama pengurusan sisa nenas di bawah RM1.

ABSTRACT

The study evaluates the existing and potential fertilizer programmes and pineapple residue management practices in order to come out with a fertilization programme which is economically viable. The fertilizer programmes adopted were: (i) application of N (176, 176, 176, and 176 kg ha⁻¹), P (11, 11, 7, and 7 kg ha⁻¹), and K (89, 89, 188, and 188 kg ha⁻¹) fertilizers at 65, 135, 191, and 233 days after planting (FP1), respectively (the usual practice); (ii) application of N (176, 176, and 176 kg ha⁻¹) P (11, 11, and 7 kg ha⁻¹) and K (89, 89, and 188 kg ha⁻¹) fertilizers at 65, 135, and 191 days after planting (FP2), respectively; and (iii) application of N (176, 264, and 264 kg ha⁻¹) P (11, 14, and 11 kg ha⁻¹) and K (89, 183, and 285 kg ha⁻¹) fertilizers at 65, 135, and 191 days after planting (FP3), respectively. Pineapple residue management practices used were: (i) in situ decomposition of pineapple residue without any interference (RM1); (ii) stacking of pineapple residue (leaves,

crowns, and peduncles) slashed, and raked from 0.6 m x 10 m beds into 0.9 m x 10 m beds (RM2-zero burn technique); and (iii) in situ burning of pineapple leaves, crowns, and peduncles (the usual practice) (RM3). Combinations of the residue management practices and fertilizer programmes gave the following treatments: RM1FP1, RM1FP2, RM1FP3, RM2FP1, RM2FP2, RM2FP3, RM3FP1, RM3FP2, and RM3FP3. Neither of the fertilization programmes (FP1, FP2, and FP3) nor residue management practices (RM1, RM2, and RM3) significantly improved fruit yield. FP2 emerged as the least expensive programme followed by FP3, and then FP1. The cheapest residue management practice was RM1, followed by RM2, and RM3. RM1FP2 emerged the most economic treatment combination. Zero-burn technique (RM2), in situ decomposition of pineapple residues without any interference (RM1), in situ burning of pineapple residues did not significantly improve fruit yield, but practicing RM1 in pineapple cultivation on tropical peat is economical. Application of N, P, and K fertilizers at 65, 135, and 191 days after planting (FP2) was cost effective as it was possible to save as much as USD 110.17 ha⁻¹, and this programme was most economically viable under pineapple residue management practice RM1.

INTRODUCTION

Malaysia is perhaps the only country in the world that largely grows pineapple (*Ananas comosus*) on peat. This practice is characterized by recycling pineapple residues before replanting through in situ burning. Presently, 17,000 hectares of peat is under pineapple cultivation (AGRIQUEST 1999/2000). Pineapples produced from this area serve both the canary and fresh market. After realizing the need to apply balanced fertilizers for a better pineapple growth and production on peat (Dunsmore 1957), several of fertilizer recommendations (Tay 1972; Tay 1973; Selamat and Ramlah 1993) have intermittently been recommended. In nutrient budget studies, Ahmed *et al.* (2000) observed that the existing fertilizer programme for pineapple cultivation on tropical peat was inappropriate. The reason being inefficient synchrony between nutrient released from applied fertilizers and optimum nutrient uptake particularly during the last stage of fertilization (263 days after planting). They estimated that 46.79 % (leaching plus accumulation) of P and 73.52 % (leaching plus accumulation) of K were unutilized. Ahmed *et al.* (1999) estimated P and K fertilizer use efficiencies of 53.21% and 29.91 %, respectively.

Although Malaysia does not locally produce sufficient fertilizers, but based on unit land area, it is reported that Malaysia is one of the heaviest users of fertilizers in the world. For 1995/96, Malaysia used 223.4 kilogram per hectare fertilizer nutrients, compared to a world average use of only 83.4 kilogram per hectare (AGRIQUEST 1999/2000). From January to September in 1998, the Malaysian fertilizer import bills for nitrogeous, phosphatic, and potassic fertiliz-

ers reached USD 107, USD 40, and USD 116 million, respectively.

Now that in situ burning of pineapple residues before replanting has been banned (Environmental Quality Act 1974 amended in 1998), time demands that pineapple fertilizer recommendations take into account interaction between fertilizer regime and crop residue management practices like zero burn or in situ mulching; an aspect that has received less consideration, even though as much as 15 Mg ha⁻¹ of pineapple residue is recycled. This study evaluates the existing and potential fertilizer programmes and pineapple residue management practices in order to come out with a fertilization programme which is economically viable.

MATERIALS AND METHODS

The study was conducted at Simpang Rengam Pineapple Estate, Simpang Rengam, Johore, Malaysia on a Hemist peat. Nitrogen (N) 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), respectively (most commonly used fertilizers in pineapple cultivation in Malaysia). The fertilizer programmes adopted were: (i) application of N (176, 176, 176, and 176 kg/ha), P (11, 11, 7, and 7 kg ha⁻¹), and K (89, 89, 188, and 188 kg/ha) fertilizers at 65, 135, 191, and 233 days after planting (FP1), respectively (the usual practice); (ii) application of N (176, 176, and 176 kg/ha), P (11, 11, and 7 kg/ha) and K (89, 89, and 188 kg ha⁻¹) fertilizers at 65, 135, and 191 days after planting (FP2), respectively; and (iii) application of N (176, 264, and 264 kg ha⁻¹), P (11, 14, and 11 kg ha⁻¹) and K (89, 183, and 285 kg ha⁻¹) fertilizers at 65, 135, and 191 days after

planting (FP3), respectively. Pineapple residue management practices used were; (i) in situ decomposition of pineapple residue without any interference (RM1), (ii) stacking of pineapple residue (leaves, crowns, and peduncles) slashed and raked from 0.6 m x 10 m beds into 0.9 m x 10 m beds (RM2-zero burn technique), and (iii) in situ burning of residues (the usual practice) (RM3). In order to estimate the amount of ash added through in situ burning of residues (R3), these parts were slashed from old pineapple stumps, raked, and collected from four representative plots of RM3 before the start of the experiment. The residues were air-dried to constant weight, burnt and the weight of ash recorded. A direct proportional relationship was assumed for estimating amount of ash added through in situ burning on a per hectare basis. The same procedure was used to estimate the amount of residue (leaves, crowns, and peduncles) added under RM1 and RM2 except that the residues were not burnt. Combinations of residue management practices and fertilizer programmes evaluated were: RM1FP1, RM1FP2, RM1FP3, RM2FP1, RM2FP2, RM2FP3, RM3FP1, RM3FP2, and RM3FP3. It must be emphasized that a treatment without residue was excluded in this study because of the following reasons: (I) Removal of pineapple residues is not practical and in Malaysia the issue of how to handle or use of pineapple residues is still open to discussion. Until value added products are developed from pineapple residues estates are unwilling to adopt this kind of residue management practice. (II) Results of Ahmed *et al.* (1999) showed no significant difference between residue removal and burning on P and K uptake or fruit yield.

The study was a 3 x 3 factorial experiment in a randomized complete block design with 4 replications. The experimental plots were 8 m x 10 m, and altogether, 480 cv Gandul (most popularly grown) suckers were planted in each of the plots. A day before the start of the experiment, peat samples were taken to a depth of 25 cm using peat augur in each of the designated experimental plots. At maturity (540 days after planting), fruits were harvested from all plots (excluding guard rows) and weighed fresh.

Soil extractable K and P were extracted using the double acid method (0.05 M HCL:0.025 M H₂SO₄) with soil to solution ratio of 1:10 for 1 hour (Modified from Van Lierop *et al.* 1980). Single dry ashing method was used to determine

total P and K in ash and residue. Phosphorus was determined using the molybdate blue method (Murphy and Riley 1962) at a wavelength of 882 nm. Potassium was determined using atomic absorption spectrophotometer. Total N in peat samples and residue were determined using micro-Kjeldahl method (Bremner 1960). The method described by Ahmed *et al.* (1999) was used to quantify the amount (kg ha⁻¹) of P and K in ash and N, P, and K in residue recycled in a cropping season.

The estimation of cost of labour associated with the following activities: slashing, raking, and stacking pineapple residues, burning pineapple residues, fertilizer application, and weeding were based on the wage system of the pineapple plantations. Farm gate market prices were used for fertilizers and other farm materials. Other costs associated with the following: preparation of suckers, suckers (cost), planting suckers, pesticides and pesticides application, hormone and hormoning, harvesting, land (rent), and maintenance were the same, and as such were excluded in the cost analysis. Interest rate of 12% on capital was used. Interest factor was calculated using the formula: $(1 + i)^{-w}$ where, *i* represents interest rate and *w* represents the number of years in attaining crop maturity (Davis and Johnson 1987).

RESULTS AND DISCUSSION

The status of N, P, and K before the introduction of treatments in the experimental plots were statistically similar (Table 1). In situ burning of leaves, crowns, and peduncles (RM3) recycled 1.31 Mg ha⁻¹ containing 18.69 and 240.43 kg ha⁻¹ P and K, respectively. In situ decomposition (RM1 and RM2) of leaves, crowns, and peduncles recycled 5.5 Mg ha⁻¹ of residue containing 70.00, 6.10 and 13.81 kg ha⁻¹ N, P, and K, respectively. At harvest, fruit yields were not statistically different for all three the residue management practices (Table 2). This observation is consistent with that of Ahmed *et al.* (1999). In their study leaf removal or burning did not show significant difference in fruit yield. Burning pineapple residue leads to addition of ash containing soluble nutrients (Ahmed *et al.* 1999). This practice is however characterized by recycling or addition of nutrients at an early stage where nutrient uptake has been observed to be generally slow (Py *et al.* 1987). In addition, high rainfall usually leads to some nutrient loss

TABLE 1
Total N and extractable P and K before experimentation

Treatment	N %	*S.E.M.	P mg kg ⁻¹	*S.E.M.	K mg kg ⁻¹	*S.E.M.
RM1FP1	1.73	0.09	30.78	2.13	402	36.69
RM1FP2	1.45	0.06	26.17	1.48	477	25.74
RM1FP3	1.37	0.05	27.71	1.53	575	62.86
RM2FP1	1.55	0.007	24.71	2.46	445	50.4
RM2FP2	1.58	0.13	33.34	2.93	450.50	41.68
RM2FP3	1.42	0.28	28.95	4.53	575.50	20.92
RM3FP1	1.31	0.16	40.01	3.87	564	40.82
RM3FP2	1.58	0.11	28.95	6.11	590	78.12
RM3FP3	1.56	0.04	34.44	7.75	534	72.03

*S.E.M: Standard Error of Mean

Note: There was no significant difference in experimental plots before experimentation (ANOVA at $P \leq 0.05$).

TABLE 2
Effect of residue management practices on fruit yield

Residue Management	Yield kg m ⁻²	*S.E.M.
RM1	5.18	0.10
RM2	5.09	0.05
RM3	5.25	0.11

*S.E.M : Standard Error of Mean

Note : No significant difference was observed between residue management practices (single degree of freedom contrast at $P \leq 0.05$).

in tropical peat through leaching and surface runoff (Funakawa *et al.* 1996; Ahmed 1999; Ahmed *et al.* 2000). These observations partly explain the non-significant effect on fruit yield for RM3 (in situ burning of pineapple residue). The practice of covering soil surface with crop residues does not only reduce nutrient losses through leaching and runoff, but also enrichment through the processes of decomposition and mineralization. The practice also ensures relatively slow nutrient release. Considering the quantity (5.50 Mg ha⁻¹) of pineapple residues recycled per cropping season (Ahmed *et al.* 2000) under RM1 and RM2, observed results were contrary to the expected response in fruit yield was expected but the contrary was the case. In fact in the course of the study, it was observed it took not less than 13 months for pineapple residues to start decomposing. Hence it is not surprising for the possibility of RM1 and RM2 not contributing sufficient amounts of N, P, and K at the right time for a meaningful improve-

ment in the uptake of these nutrients and fruit yield.

The estimated labour cost associated with RM1, RM2, and RM3 were USD 7.49 ha⁻¹, USD 37.37 ha⁻¹, and USD 11.23 ha⁻¹, respectively with RM1 being the least expensive residue management practice followed by RM3 and RM2 (Table 3). This observation was obviously due to the differences involved in handling the residues before replanting and weed control. While no cost was involved in managing the residues except weed control (USD 7.49 ha⁻¹) under RM1, under RM3 it cost USD 3.74 ha⁻¹ to burn pineapple leaves, crowns, and peduncles, and USD 7.49 ha⁻¹ for weed control. In the case of RM2, slashing of leaves cost USD 22.46 ha⁻¹. Raking and stacking leaves, crowns, and peduncles

TABLE 3
Costs associated with pineapple residue management practices

	RM1	RM2	RM3
	USD ha ⁻¹		
Slashing of leaves	0	22.46	0
Raking and packing of leaves	0	11.1	7.0
Burning of leaves	0	0	3.74
Weeding	7.49	3.74	7.49
Pollution through burning of pineapple leaves ¹	0	0	638.20
Total	7.49	37.37	649.43

¹Husni *et al.* 1999

under RM2 cost USD 11.23 ha⁻¹, and USD 3.74 ha⁻¹ for weed control.

Comparing the cost of labour associated with RM2 (US\$ 37.37 ha⁻¹) to that of the usual pineapple residue management practice RM3 (USD 11.23 ha⁻¹), it can be realized that an additional cost of USD 26.14 ha⁻¹ will be required to consider RM2 as an alternative choice to RM3. But the reverse would be the case if the cost of pollution (open burning of pineapple residues) estimated at USD 626.97 ha⁻¹ (Husni *et al.* 1999) associated with RM3 is taken into account. In the case of RM1 (USD 7.49 ha⁻¹) versus RM3 (USD 11.23 ha⁻¹), the difference was only USD 3.74 ha⁻¹. Although this difference is relatively small, the accompanied cost of pollution in practicing RM3 renders RM1 an economic residue management practice. Comparing RM2 (USD 37.37 ha⁻¹) and RM1 (USD 7.49 ha⁻¹), as much as USD 29.88 ha⁻¹ could be saved if RM1 is adopted. In other words, the same amount will be forgone for adopting RM2. Table 4 shows the effect of fertilizer programmes FP1, FP2, FP3 under RM1, RM2, and RM3 on fruit yield. The effect of FP1, FP2 and FP3 on fruit yield was not significant. Razzaque *et al.* (1999b) recorded significant increase in fruit yield only when N rate ranged between 800 and 1000 kg ha⁻¹. This ranged however did not significantly increase N uptake (Razzaque *et al.* 1999a). Studies have shown that cultivar Gandul P requirement on peat is generally low (Tay 1972, 1973; Selamat and Ramlah 1993; Razzaque 1999) and hence, rarely respond to P application, but the presence of P enhances or

TABLE 4

Effect of fertilizer regimes under different pineapple residue management practices on fruit yield

Treatment	Yield (kg m ⁻²)	*S.E.M
RM1FP1	5.30	0.28
RM1FP2	5.16	0.06
RM1FP3	5.09	0.16
RM2FP1	5.21	0.08
RM2FP2	5.03	0.02
RM2FP3	5.03	0.11
RM3FP1	5.18	0.08
RM3FP2	5.24	0.14
RM3FP3	5.34	0.30

*S.E.M : Standard Error of Mean

Note : No significant difference was observed between treatments (single degree of freedom contrast at P ≤ 0.05).

increases the absorption of K in peat (Dunsmore 1957). At lower rates (203, 305 kg K ha⁻¹), Selamat and Ramlah (1993) observed a significant linear response for fruit weight but at higher rates (442, 662, 883, and 1104 kg K ha⁻¹), such relationship was not obtained but rather, K uptake and fruit yield depressed at higher doses particular at 883 and 1104 kg K ha⁻¹ (Razzaque 1999).

The respective costs associated with fertilizer programmes FP1, FP2, and FP3 were estimated at USD 395.18 ha⁻¹, USD 285.01 ha⁻¹, and USD 387.02 ha⁻¹ (Table 5). Comparing FP2 to the usual fertilizer programme FP1, as much as USD 110.17 ha⁻¹ was saved under FP2. This difference was obviously due to the difference in the amount of fertilizers used and their cost of application. Under FP1 the total costs of using 704 N, 36 P, and 554 K kg ha⁻¹ and their cost of application were estimated at USD 362.55 and USD 32.63, respectively, while that of FP2 amounted to USD 260.54 and USD 24.47, respectively. The comparison of FP3 and FP1 re-

TABLE 5
Costs associated with pineapple fertilization programmes

Fertilizer Program- Urea me	Urea	MOP	CPR USDha ⁻¹	Fertilizer application	Total
FP1	242.82	102.44	17.29	32.63	395.18
FP2	182.12	67.52	10.90	24.47	285.01
FP3	242.82	102.44	17.29	24.47	387.02

vealed a difference of only USD 8.16 ha⁻¹. The difference was from N, P, and K application (Table 5) as the quantities applied under these programmes (FP3 and FP1) were the same ex-

TABLE 6

Overall costs associated with pineapple fertilizer programmes under different pineapple residue management practices

Treatment	Total cost (USD ha ⁻¹)
RM1FP1	402.67
RM1FP2	292.50
RM1FP3	394.51
RM2FP1	432.55
RM2FP2	322.38
RM2FP3	424.39
RM3FP1	1,033.38
RM3FP2	923.21
RM3FP3	1,025.22

cept that the frequency of application for FP3 and FP1 were 3 and 4, respectively.

Table 6 shows the total cost associated with each of the 9 treatment combinations. The combination RM1FP2 was the least expensive (USD 292.50 ha⁻¹) while RM3FP1 was the most expensive (USD 1,033.38 ha⁻¹). The respective costs associated with the treatment combinations; RM1FP2, RM2FP2, and RM3FP2 were generally lower than the rest of the treatments (Table 6).

CONCLUSION

Zero burn technique (RM2), in situ decomposition of pineapple residues without any interference (RM1) or in-situ burning of pineapple residues (RM3) did not significantly improve fruit yield but practicing RM1 in pineapple cultivation on tropical peat is economical. Application of N, P and K fertilizers at 65, 135 and 191 days after planting (FP2) is economically viable as it is possible to save as much as USD 110.17 ha⁻¹, and this programme is economically viable under pineapple residue management practice RM1.

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