Land Application of Palm Oil Mill Effluent (POME) on Oil Palm Using A Tractor-Tanker and Flatbed System

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RINGKASAN

Kajian perbandingan penggunaan efluen kilang sawit (POME) sebagai baja organik dengan baja bukan organik terhadap kelapa sawit dijalankan dengan menggunakan kombinasi sistem 'tractor-tanker' dan 'flatbed'.

Hasil kajian selama empat tahun menunjukkan pengeluaran hasil BTS bagi plot yang menggunakan POME ialah 21.15 tan/hektar/tahun dan adalah setanding dengan plot yang menerima baja bukan organik dimana mengeluarkan hasil BTS 20.66 tan/hektar/tahun. Status pemakanan dan pertumbuhan pokok juga didapati setanding bagi kedua-dua plot.

Pengujian penggunaan POME dengan kadar yang digunakan terhadap alam sekitar juga menunjukkan tidak ada pencemaran berlaku pada kualiti air dalam tanah dan didapati adalah sejajar dengan penemuan penyelidikan hingga kini.

INTRODUCTION

Palm oil mill effluent (POME) has been shown to be a good source of organic fertilizer for crop production since it has significant amount of plant nutrients and is currently available in large quantities at low cost. It is projected that by the year 2000 Malaysia will produce 8 million tonnes of crude palm oil and correspondingly about 24 million tonnes of POME will be generated (Zin *et al.*, 1988). The tremendous volume of POME produced by the palm oil industry could be recycled as inorganic fertilizer replacement for most crops including oil palm which will save the industry and the country millions of ringgit in foreign exchange. Land application of POME has provided the oil palm industry with a cost-effective approach in waste utilization and substantial savings in fertilizer costs (Lim, 1987).

Several investigations have confirmed the benefits of land application of POME on palm growth and yield with negligible effects to the environment (Lim, 1987; Mohd. Tayeb *et al.*, 1987; Zin *et al.*, 1988; Gurmit *et al.*, 1989). Various systems of application of POME currently being adopted by the industry on a commercial scale include sprinkler/pipe irrigation, flatbeds, furrows, and tractor/tanker. However, each system of land application of POME varies in cost and it has been found that the tractor/tanker system is the cheapest in terms of capital and operating costs (Yeow and Zin, 1981 and Zin *et al.*, 1988). This system is also suitable for commercial application in an oil palm area with a flat to gently undulating terrain.

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This paper reports on a trial to monitor the effects of land application of anaerobic tank digested POME using a combination of tractor-tanker and flatbed system. The palm performance and nutrient uptake, groundwater quality, and soil properties, are included in the assessment.

MATERIALS AND METHODS

The trial was set up in late 1987 in a FELDA scheme in Kerteh, Terengganu to study the effects of land-application of POME on palm performance, soil properties and groundwater quality using the flatbed and tractor/tanker system.

The trial was situated on flat to gently undulating terrain and located in the vicinity of FELDA Kerteh palm oil mill. The soil is a Rengam series (Typic Paleudult) planted with oil palms in 1976.

Treated plots applied with anaerobic tank-digested POME were compared with control plots receiving inorganic fertilizers. The POME treated area comprised 400 recorded palms where a flatbed was constructed on alternate interrows and was bounded by four palms as shown diagrammatically in *Figure 1*. The size of the flatbed was 3 m x 3 m x 0.3 m depth. No supplementary fertilizers were applied to any of the POME treated palms. The adjacent area was used as control plots where routine fertilizer applications were made using the normal FELDA rates (*Table 1*).

In the application of POME, the tractor/tanker travelled along the 'harvester' path and POME was discharged into the flatbeds along alternate avenues. The rate of application was 500 litres per station and six applications were made per year at bimonthly intervals. The rate was determined based on the annual nitrogen requirements of the palm. POME application commenced in December 1987.

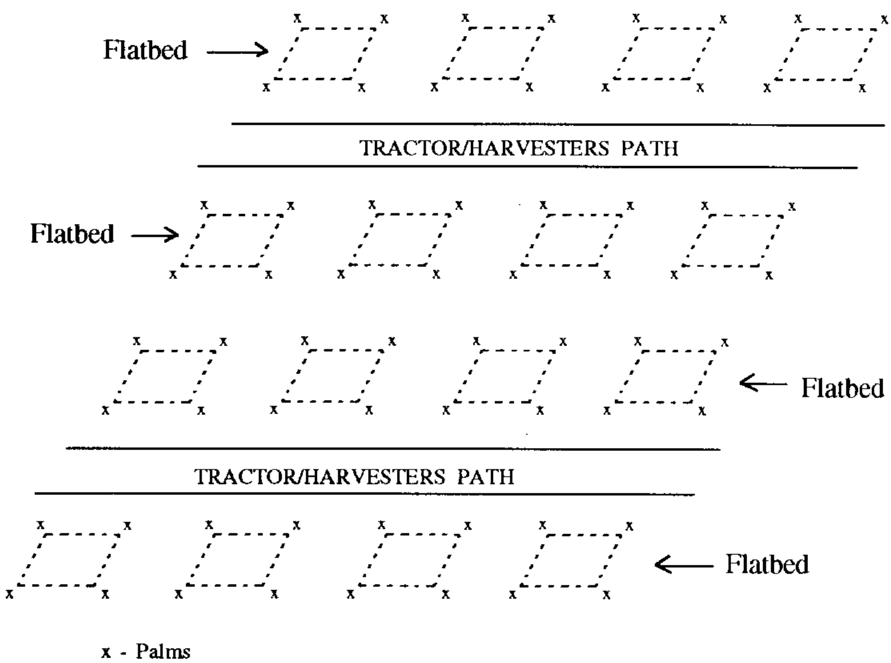

Figure 1. Tractor-Tanker and flatbed system

Two PVC tubewells (12 cm diameter) were buried vertically to a depth of 3 m at two separate sites within POME treated area and the control to monitor the groundwater.

Palm performance was assessed based on FFB yield record, vegetative measurement and foliar analysis. Foliar samplings and vegetative measurements were carried out yearly, for all the treated and control areas.

Samples of anaerobic tank-digested POME and groundwater were collected bimonthly for chemical analysis. Soil samples were collected at various locations and depths immediately after the trial had been terminated. For each plot, sub-samples were taken and bulked into a composite sample. The data on chemical composition of digested POME and groundwater presented in this paper were mean values of several readings collected over a period of four years.

RESULTS AND DISCUSSION

Chemical Composition of POME

The chemical composition of anaerobic tank digested POME used in this study is given by *Table 2*. There was a fairly wide variation in the parameters analyzed due mainly to seasonal fluctuation in the monthly rainfall intensity causing dilution of the POME, especially during the monsoon season when all the readings were low.

The pH value was high with a mean of 7.4. The nitrogen and potassium contents were high and those for calcium and magnesium were moderate. Phosphorus content was low. The heavy metals were present only in trace quantities. The results obtained were in the range reported by other researchers (Zin, *et al.* 1983 and Lim *et al.*, 1993).

Ammonium-N and Nitrate-N content were fairly high with mean values of 120 and 85 ppm respectively.

Effect on Yield and Yield Components

Results on FFB yield components are shown by *Table 3*.

The results over four years indicated that the cumulative yield for POME treated area was 2.4% higher. Correspondingly, there was a 4.2% increase in

TABLE 1. FERTILIZER RATE IN CONTROL AREA (kg/palm/yr)

Year	Urea	M.O.P	*FELDA Mixture
1987	1.63	2.80	-
1988	1.60	2.83	-
1989	1.37	3.20	-
1990	1.50	2.10	-
1991	-	1.75	6.56

*Contain: N : P : K : Mg – 9.6, 4.8, 7.6, 2.4

+Felda rate applied in particular area (block two)

TABLE 2. CHEMICAL COMPOSITION OF ANAEROBIC TANK DIGESTED POME

Parameter	Concentration* Range	Mean
pH	6.8 – 7.9	7.4
N	123 – 3483	1084
P	3 – 121.5	41.8
K	675 – 4063	1255
Ca	91 – 1156	496
Mg	178 – 783	319
B	0.1 – 3.1	0.9
NH4 - N	1.4 – 273.7	120
NO3-N	10.5 – 252.5	85
Fe	2.5 – 546	70
Mn	0.5 – 31.3	7.4
Cu	0.1 – 5.2	1.7
Zn	0.1 – 8.3	2.4
Pb	0 – 0.06	0.04

*All concentrations in ppm except pH

average bunch weight, but a 2% reduction in bunch number in the POME treated plots as compared to the control. The mean FFB yields over four years for POME treated area and the control were 21.15 and 20.66 tonnes/ha/year respectively.

Effect on Leaf Nutrient Levels

The yearly leaf nutrient levels for the POME treated plots and the control were compared (*Table 4*). Generally the leaf nutrient levels of both plots were satisfactory except for P and K which were slightly low. The trend for all nutrients was more or less similar for POME treated plots and the control. The decrease in leaf K was quite consistent with the increase in leaf Mg. Koh and P'ng (1981) observed an increase in ratios in soil exchangeable K and Mg with increase in POME rates applied and this may explain the antagonistic relationship between K and Mg. The comparable yield and leaf nutrient levels for the POME treated plots and the control indicated that the POME had the capability of supplying adequate nutrients for the palm. However, the benefit of the water component in POME has not been assessed in this study. Lim (1987) found that the application of POME improved soil moisture retention through improved soil structure and moisture conservation due to the direct addition of water.

TABLE 3. EFFECT OF TANK DIGESTED POME APPLICATIONS ON YIELD COMPONENTS OF OIL PALM

Treatment	1988	1989	1990	1991	1988-1991 Total	% of Control
a. FFB, Yield (tonne/ha)						
Control	22.46	17.44	24.2	18.54	82.64	(100.0%)
POME	21.24	17.11	24.54	21.73	84.62	(102.4%)
b. Average Bunch Weight (kg)						
Control	19.92	19.61	21.4	22.71	20.91	(100.0%)
POME	21.11	20.61	23.04	23.35	21.78	(104.2%)
c. Average Bunch Number (bunch No./ha)						
Control	1227	968	1231	889	1079	(100.0%)
POME	1150	904	1159	1013	1057	(98.0%)

Effect on Vegetative Growth

The vegetative growth of the palms, as expressed by the rachis length, leaf area, and frond dry weight (*Table 5*) over four years in the POME treated plots showed comparable growth with the control plot. As reported by other researchers there was no distinct difference in the vegetative growth parameters (Koh and P'ng, 1981). This might be due to the seasonal fluctuations especially rainfall, which influenced the vegetative growth.

Effect on Groundwater Quality

Table 6 shows the chemical composition of groundwater samples taken from the PVC tube wells for both areas. The results obtained did not show any significant increase in any of the parameters investigated when compared to the control. This indicated that the rate of POME applied was within the safe limit. In addition, the soil as a medium, is an effective natural filter, retaining nutrients in the soil matrix for continuous uptake by the palms. The results obtained confirmed the findings of other researchers that raw and digested POME does not contribute to pollution of the environment (Zin *et al.*, 1981; Mohd. Tayeb *et al.*, 1987; and Lim *et al.*, 1993).

The level of NO_3-N was found to be slightly higher in the POME treated plots as compared to the control. However, the level was still low and within acceptable and safe limit. The slightly higher value of NO_3-N in the treated plots was probably due to leaching through the soil profile.

Effect on Soil Chemical Properties

The chemical analysis of soils sampled at 0-15 cm, 15-30 cm and 30-60 cm depth at various distances from the flatbed are shown in *Table 7*. It is interesting to

TABLE 4. LEAF NUTRIENT LEVELS[+] IN CONTROL AND POME TREATED PLOTS

	%N		%P		%K		%Mg		%Ca	
Year	Control	POME	Control	POME	Control	POME	Control	POME	Control	POME
1988	2.46	2.41	0.119	0.133	0.89	0.94	0.31	0.38	0.67	0.67
1989	2.55	2.52	0.142	0.144	0.85	0.78	0.32	0.38	0.59	0.61
1990	2.50	2.56	0.138	0.143	0.78	0.80	0.38	0.41	0.58	0.53
1991	2.64	2.72	0.132	0.145	0.96	0.97	0.35	0.39	0.61	0.51
1992	2.51	2.51	0.142	0.132	0.81	0.79	0.45	0.46	0.45	0.41

[+] All leaf samples taken in January yearly

[*] Control - normal estate manuring

note that POME application significantly increased soil pH within the flatbeds especially at the 15-30 cm depth. This finding was in agreement with earlier investigations reported by Zulkifli and Shamsuddin (1985) and Lim (1987). The former researchers found that the maximum pH rise was achieved after two months of POME application, after which the value decreased. In this study, it was observed that the POME applied was diluted during the monsoon season, especially during December, where all the flatbeds applied with POME were flooded with water and overflowed into the field. Away from the flatbeds, there was no increase in soil pH.

The nutrient levels within the flatbeds applied with POME increased by two to eight folds. Soil Mg increased significantly by eight folds and the extractable K and Ca increased by four to five folds. The available P content in the flatbed treated with POME also increased when compared with the control, especially in the top 0 - 15 cm layer. Total N within the flatbeds increased seven folds and this might be due to the high N content of POME. The nutrient levels at other sites away from the flatbeds were not affected and remained comparable to the control. Oil palm being a surface feeder was observed to have more feeder roots concentrated within the flatbeds and at the periphery, indicating better availability of nutrients. Lim (1987) observed changes in soil pH with distance away from the flatbeds and found that the zone of pH changes covered an area as far as 60-90 cm from the flatbed.

CONCLUSION

Results obtained from this study have shown the viability of using digested POME for land application to oil palm. The study confirmed some of the earlier findings on the beneficial effects of land

TABLE 5. EFFECT OF TANK DIGESTED POME APPLICATION ON VEGETATIVE COMPONENTS (Frond 17) OF OIL PALM

Year	Treatment	Leaf Area (m^2)	Dry Wt (kg)	Frond Length (cm)
1988	POME	18.18	4.73	660
	Control	19.24	4.70	671
1989	POME	18.85	4.72	670
	Control	19.75	4.86	672
1990	POME	19.80	5.00	625
	Control	20.20	5.03	629
1991	POME	20.62	5.23	658
	Control	21.97	5.12	671

TABLE 6. ANALYSIS OF GROUNDWATER AT MONITORING SITES

Parameter	Concentration*	
	POME	Control
pH	6.7	6.5
Total N	4.5	4.2
P	T	T
K	7.8	5.9
Ca	11.7	8.6
Mg	7.7	5.7
B	T	T
NH4-N	2.5	2.2
NO3-N	13.2	7.9
Fe	1.18	1.05
Mn	0.01	0.02
Cu	0.02	0.03
Zn	0.27	0.36
Pb	T	T

*All concentrations in ppm except pH
T = Trace

application of POME on palm performance and soil properties. When POME was applied at a controlled rate, there was no indication of pollution to groundwater. The tractor-tanker system of POME application using flatbeds in this trial was found to be convenient and practical since it was easy to control and regulate for even distribution of POME. Furthermore it did not leave any unpleasant residue on the soil surface in the field. More importantly, it did not cause any disruption in routine field operations.

Based from observations made in this study, and observations made in earlier findings as reported by other researchers, it may be necessary to apply supplementary doses of inorganic fertilizers after continuous application of POME. This is to counter the shortage or possible imbalance of nutrient for optimum yield and returns.

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TABLE 7. CHEMICAL PROPERTIES OF SOIL SAMPLES TAKEN AT VARIOUS DISTANCES AND SOIL DEPTHS

Location	Depth	%N		Av. P (ppm)		K^+		Ca^+		Mg^+		pH	
	(cm)	POME	Control	POME	Control	POME	Control	POME	Control	POME	Control	POME	Control
Inside the flatbed	0 - 15	1.14	0.12	134.0	60.0	0.56	0.08	7.12	0.88	3.65	0.30	4.91	4.90
	15 - 30	0.74	0.12	84.0	70.0	0.63	0.08	3.80	0.78	2.54	0.31	5.52	4.85
	30 - 60	0.43	0.08	32.1	60.0	0.51	0.26	2.25	1.02	1.32	0.31	5.19	4.95
Between flatbed and palm	0 - 15	0.14	0.12	50.0	30.0	0.24	0.27	0.96	1.28	0.32	0.41	4.75	5.04
	15 - 30	0.13	0.12	2.5	40.0	0.25	0.24	0.97	1.04	0.30	0.29	4.79	4.94
	30 - 60	0.24	0.09	2.0	20.0	0.23	0.22	0.86	0.93	0.25	0.31	4.75	4.74
At weeded circle	0 - 15	0.12	0.12	130.0	80.0	0.29	0.26	1.12	1.09	0.46	0.54	4.99	4.98
	15 - 30	0.12	0.12	100.0	70.0	0.30	0.22	1.03	0.86	0.45	0.54	4.88	4.92
	30 - 60	0.13	0.09	40.0	10.0	0.29	0.74	1.29	0.26	0.52	0.39	4.84	4.81

Samples taken in April '92 (4 months after the trial terminated)
+ (milliequivalent/100 g soil)

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