OPTIMIZING THE USE OF OIL PALM BY-PRODUCT (EFB) AS FERTILISER SUPPLEMENT FOR OIL PALM

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1. INTRODUCTION

The oil palm is one of the most versatile oilseed crops grown in the tropical world. Besides palm oil and palm kernel oil, the oil palm industry also generates a number of by-products most of which have well established uses. Palm kernel cake, for instance, is an established animal feed; the fibre and shells are burnt as fuel in the boilers to raise steam and the residual boiler ash is used for surfacing estate roads; bunch ash is a valuable potash fertiliser whilst the pruned fronds and, to a lesser extend, the trunks and stumps, are recycled in the field as organic matter.

In maintaining the position of Malaysia as the leading producer of palm oil, it is imperative that concerted efforts are made to reduce its cost of production. To achieve this, a number of approaches are required, not the least of which is the maximization of by-product utilization. In this respect, the EFB, which is produced in large quantities, need to be optimally exploited to obtain maximum benefits from their uses.

In the palm oil milling process, one tonne of fresh fruit bunches (FFB) produces about 0.22 tonne empty fruit bunches (EFB). This is a potentially serious source of air pollution. With the present stringent DOE regulation on air pollution, much of the EFB produced by palm oil mills is used as fertiliser supplement for oil palm.

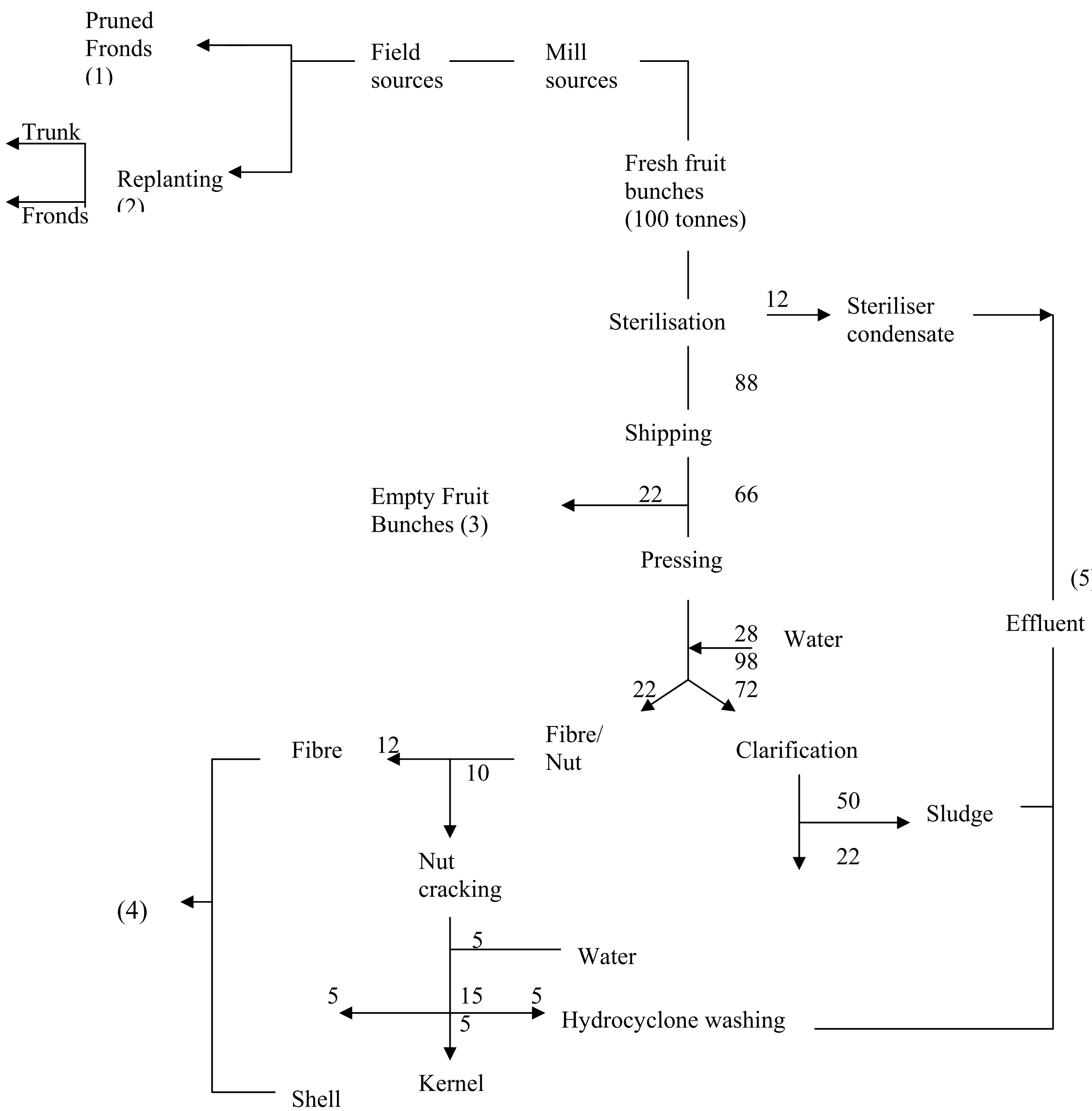
In the recent years, there has also been a great deal of interest in the utilisation of the empty fruit bunches (EFB). Many plantation companies have developed methods to return empty bunches to the field because the result of agronomic research have shown positive effect of empty bunch mulching on oil palm productivity. (Gurmit et al. 1989; Lim & Chan, 1989; Loong et al., 1987; Loh K.H. 1987, Mohd T.D. et al. 1987; Mohd H.T. 1991).

The utilization of the EFB by-product as organic mulching and fertilizer supplement for oil palm will be emphasized in this paper.

2. QUANTITY AND AVAILABILITY OF EMPTY FRUIT BUNCH (EFB)

In oil palm plantations, large quantities of by-products in the form of empty fruit bunch (EFB) is readily available as sources for maintaining organic matter at the necessary levels established originally by the legume covers. The types of commonly available oil palm by-products are shown diagrammatically in Figure 1.

Figure 1 : Diagrammatic Representation of Available Oil Palm By-products



Notes : Values in bracket ( ) = types of wastes of fresh fruit bunches. The other values indicate the quantity (tonnes) of materials added or residue/product obtained.

2.1 Quantity of Empty Fruit Bunches (EFB)

During stripping of 88 tonnes of Fresh Fruit Bunches (Figure 1), about 22 tonnes will end up as empty fruit bunches by-product, which either partially dewatered and used as a fuel in the boilers or recycled back to the field as mulch for oil palms.

2.2 Nutrient Compositions in Empty Fruit Bunch (EFB)

As tabulated in Figure 1, fresh fruit bunches (FFB) contributes about 22 % of empty fruit bunch (EFB), which contain of a big quantity of plant nutrition. However, the nutrient content of EFB is quite variable as reported by various sources.

The contents of nutrients N, P, K and Mg in EFB and POME from various sources are given in Table 1.

Table 1 : Nutrients content in EFB from various sources

Item	**Sources**	**Nutrient content (%) on dry weight**			
		N	**P**	**K**	**Mg**
EFB	Corley, 1971	0.35	0.03	2.29	0.18
	Chan, 1980	0.34	0.03	2.21	0.17
	Gurmit, 1982	0.80	0.10	2.40	0.20
	Ebor, 1985	0.66	0.06	1.20	0.20
	Mean	**0.54**	**0.06**	**2.03**	**0.19**

The empty fruit bunch (EFB) is a good source of organic matter and plant nutrients. From the above table, the EFB constitutes a large number of K followed by N, Mg and P.

3. THE USE OF EFB AS FERTILISER SUPPLEMENT

Many research findings have shown that oil palm by-product of empty fruit bunch (EFB) is good source of plant nutrients. Their applications to land as fertiliser supplement for crops especially oil palm was found to be beneficial to palm performance and soil physical and chemical properties.

3.1 Empty Fruit Bunch (EFB) as Mulching for Oil Palm

The application of empty fruit bunch (EFB) as an organic mulch in oil palm has been receiving increasing attention in recent years. Mulching is the application of materials on the surface to reduce soil temperature and conserve soil moisture to improve growth and yield of plants besides supplying varying amount of nutrients as they decompose.

The underlining reason is the enforcement of specific limits on air pollution which will subsequently prohibit EFB incineration. Though research on the utilisation of EFB had been ongoing for some times, it was only in the last decade that concerted efforts were directed to fully exploit its benefit.

It has been calculated that EFB mulching at about 27 tonnes per ha is equivalent to present manuring practices with inorganic fertilisers, with some adjustment for unbalance (Loong, 1987).

3.1.1 System of EFB Mulching (Application)

The application of Empty Fruit Bunch (EFB) is normally based on the age of palm to be applied. There are 3 categories of EFB application, namely for Immature palms (1-3 yrs), young mature palms (3-5 years) and fully mature palms (> 5 years).
The details of EFB application for these categories are shown in Table 2 below.
Table 2 : Application of EFB mulching

Immature palms (0-2 years)	**Young mature palms (3-5 years)**	**Fully matured palms (> 6 years)**
EFB should be placed in a single closely packed layer around the palm	EFB should be placed in arising from 1.5 to 2.2 m away from the palm base in a single closely packed layer	EFB may be placed anywhere in the interrows, but away from the palm fronds and harvester path.
The EFB mulching should be from 0.2 to 1.5 m away from the palm base		EFB should be in a single pile closely packed preferably in rectangular shape of 1.5 m x 4.5 m per palm

The area of EFB application on fully mature palms on flat/undulating non-terraced areas and terraced areas are illustrated in Figure 2 and 3.

The rate of EFB application depends on the age of the palm and soil conditions. However, a guide to the rate of EFB mulching for various palm ages and soil conditions is given in Table 3 below.

Table 3 : The rate of EFB mulching (ton/ha) for various palm ages and soil conditions

Palm and soil conditions	**Palm Age**		
	(0-1 yr)	**(1-8 yr.)**	**(> 8 yr.)**
Normal palms and normal soil conditions	15	40	40
Poor palms and poor soil conditions	25	40	60

Loong (1987), suggested the rate of EFB mulching with additional fertiliser supplement for commercial practices as presented in Table 4.

Table 4 : Optimum EFB mulching rate for commercial practices on inland and coastal soils

Pam age and soil	**EFB mulch (t/ha/ round)**	**Fertiliser supplements (kg/ha/round)**		**Frequency**
		Nitrogen	**Phosphorus (as CIRP)**	
Immature				
Coastal *	25	102 (Urea)	34	First round immediately after planting. Second round after 14 mths
Mature				
Coastal	37	102 (Urea)	34	Annual
Rengam*	37	444 (AS)	222	

* Can be taken as representative of inland soils

Three common steps are involved in EFB applications in the field they are EFB transporting (to transport the EFB from the mill to the selected area), EFB dumping (to dump the EFB to the nearest point of the palms) and EFB stacking (to stack the EFB to the area of application).

4 BENEFITS OF EFB MULCHING AND COMPOSTED EFB

4.1 Benefits of Empty Fruit Bunch (EFB) Mulching

Organic mulching such as EFB has long been recognized as beneficial to crop production. The breakdown of organic matter by microorganism is a relatively slow process and this leads to slow release of nutrients back to the soil.

Recycling plant nutrients in mulch is one of the best means for maintaining soil productivity. Mulching with EFB improves vegetative growth and yield (Chan et al., 1980; Loong et al. 1987; Gurmit et al. 1989 and Lim et al., 1989).

The benefits of EFB mulching on soil include improvement in soil structure due to better aeration, increased water holding capacity, and increase in soil pH. In addition, it prevents rain splash, soil wash and so reduces erosion and nutrient losses and moderates soil temperatures.

In view as a supplement and/or substitute for inorganic fertilisers, most current research efforts and commercial field applications are concentrated in the older mature areas where the bulk of inorganic manuring lies.

However the application of EFB mulching during immaturity stage have improved the vegetative growth as reported by Loong (1987) and shown in Table 5 below.

Table 5 : Effect of EFB mulching on Frond Dry Weight. Leaf Area Index (LAI) and Petiole Cross Section in Various Soils

Soil and Treatment	Parameter					
	Frond dry wt. (kg)		LAI		Petiole-X-section (cm^2)	
	Immature	Young mature	Immature	Young mature	Immature	Young mature
Rengam						
Mulch	1.25	2.00	1.63	4.02	10.3	17.6
Inorganic Programme	1.19	1.60	1.29	2.91	9.0	13.8
Briah						
Mulch	1.48	2.48	2.98	4.31	12.6	22.4
Inorganic Programme	1.43	2.47	2.82	4.64	12.1	22.3

Source : Loong et al. (1987)

Lim (1989) reported that work on EFB mulching at time of planting on inland soils have also indicated the additional benefits in terms of better growth, as stated in Table 6.

Table 6 : Effect of EFB mulching at time of planting on fertile cross section and leaf area on 2 inland soils

Soil and Treatment	**Parameter (at 24 months after planting)**	
	Petiole Cross Section (cm^2)	**Leaf Area (m^2)**
Malacca		
Mulch	7.46	2.23
Inorganic Programme	6.47	1.90
Rengam		
Mulch	8.54	2.29
Inorganic Programme	7.47	2.18

Earlier work carried out by Chan (1980) had indicated that there was an increase in yield when EFB was applied (as shown in Table 7).

Table 7 : Effect of EFB mulching on FFB yield on Malacca and Rengam Series

Soil and Treatment	**Yield**	
	FFB yield (t/ha/yr)	**% increase over control**
Malacca	**(Mean 24 months)**	
Mulch	20.18	35
Inorganic Programme	19.50	
Rengam	**(Mean 22 months)**	
Mulch	15.28	3
Inorganic Programme	14.84	

Source : Chan et al. (1980)

Loong (1987) reported that yield responses to fertiliser application in EFB mulching were enhanced and showing that the responses were more distinct in inland than coastal soils (Table 8).

Table 8 : Effect of EFB Mulching on FFB yield in Inland (Rengam) and Coastal (Briah) soils

Soil and Treatment	Year of harvest and Yield (FFB/t/ha)			
	2	% Increase	3	% Increase
Rengam				
Mulch	30.6	18	29.1	24
Inorganic Programme	25.9		23.4	
Briah				
Mulch	27.8	8	39.6	8
Inorganic Programme	25.7		36.7	

Source : Loong et al. (1987)

However better yield responses of EFB mulching (>15% over the control) on Coastal soils have also reported by Gurmit (1989), as shown in Table 9 below.

Table 9 : Effect of EFB mulching on FFB yields on Lunas and Akob series

Soil and Treatment	Yield	
	FFB yield (t/ha/yr)	% increase over control
Lunas	(Mean 4 years)	
Mulch	22.9	23
Inorganic Programme	18.6	
Akob	(Mean 3 years)	
Mulch	31.1	17
Inorganic Programme	26.6	

Source : Gurmit (1989)

Lim (1989), indicated that yield responses on marginal soils (shallow soils) and earlier application of EFB (at time of planting) were much higher than suitable soil (Table 10).

Table 10 : Effect of EFB mulching on FFB yields on Malacca and Rengam Series

Soil and Treatment	Yield	
	FFB yield (t/ha/yr)	% increase over control
Malacca (at time of planting)	(Mean 9 years)	
Mulch	19.25	95
Inorganic Programme	10.98	
Rengam (at onset of maturity)		
Mulch	25.25	7
Inorganic Programme	23.59	

Source : Lim et al. (1989)

In general, EFB contributes the large number of K and N for 2.03% and 0.54% respectively (average of 4 records in Table 1). The fertilizer equivalent values per 1 tonne (dry wt.) of empty fruit bunch (EFB) are shown in Table 11.

Table 11: Estimated Fertilizer Equivalent Value per 1 tonne dry wt. of EFB

Fertiliser	**Equivalent (kg)**	**Price/kg (RM)**	**Fertiliser value (RM)**
Ammonium nitrate	16	0.33	5.30
G. Rock Phosphate	2	0.26	0.50
Muriate of Potash	34	0.56	19.00
Kieserite	7	0.42	2.90
Total			**27.70**

(Fertilizer price is for first half of 2000 in Central region of Malaysia : AAR unpublished)

Citing the example of one of our estates (2000), 1 tractor (with trailer) has been found to be able to transport 8 trips of 6 mt EFB per trip per trailer. This is equivalent to 48 mt EFB per day per trailer, which is sufficient for 1 ha of EFB applications (40 ml. EFB/ha).

The transport cost for the EFB is RM4.00/mt, thus the transport cost for the day is RM4.00 x 48 mt = RM1.92 per day on equivalent to 230.00 per ha.

With the stacking productivity of 13 stations per man-day (1 station for 4 palms), the labour cost for stacking is 13 x RM1.95/station = RM25.35 per manday or equivalent to RM67.30 per ha.

Thus the total cost of EFB application is RM230.00 + RM67.30 = **RM297.30/ha**

4.2 Utilisation of Composted Empty Fruit Bunch (EFB)

As the usage of EFB mulching faces various limitations, the alternative use of composted EFB may therefore be useful. A preliminary study achieved a weight reduction of about 40% but a loss of about half the nutrient value of fresh EFB.

Composing of fresh empty fruit bunch (EFB) in 3-5 tonne heaps for a period of 8-10 months in the oven, indicated that the nutrient concentrations and pH generally increased but C/N ratio, temperature, weight and volume decrease with time (Lim, 1989).

The chemical properties, weight and volume and temperature and moisture content, changes after 32 weeks of composting EFB are summarised in Tables 12, 13 and 14 respectively.

Table 12 : Chemical property changes after 32 weeks of EFB composting.

Timing	Chemical Properties							
	pH	% C	% N	C/N	% P	% K	% Mg	% Ca
3 weeks after composting	6.58	39.78	1.16	35.90	0.104	2.38	0.15	0.25
12 weeks after composting	7.18	36.64	1.45	26.70	0.177	2.90	0.25	0.37
32 weeks after composting	7.13	30.57	2.22	14.47	0.355	2.01	0.67	1.69

Source : Lim, 1989

Table 13 : Weight changes of various treatment after 32 weeks of EFB composting

Treatment	Initial wt. (tonnes)	Wt. after 32 weeks (tonnes)	Initial Value (%)	Value afer 32 weeks (%)
No turning	5.84	1.56 (27)	100	22
Weekly turning	5.60	1.44 (26)	100	18

Source : Lim, 1989 ( ) % of initial weight

Table 14 : Temperature (^oC) and moisture content (%) changes of various treatment at 1, 12 and 32 weeks of EFB composition

Timing/treatment	Tempeature (^oC)		Moisture content (%)	
	No turning	Weekly turning	No turning	Weekly turning
1 (3) weeks after composting	59	62	49	46
12 weeks after composting	47 (79)	64 (103)	62 (126)	59 (117)
32 weeks after composting	35 (59)	37 (60)	69 (141)	53 (115)

( ) % over 1 week after composting

In general, composting of fresh EFB has some advantages.

- reduction in weight and volume
- possibility of using compost as a valuable product
- composting during wet periods when EFB mulching is difficult and distribute the compost when field conditions becomes favourable.

Composting can be briefly described as an aerobic process involving microbial conversion of organic matter into a humus residue (plus new microbial mass) with liberation of carbon dioxide and heat.

With higher nutrient content and lesser weight and volume as shown in Table 11 and 12 above, the composted EFB could be mulched at lower rate to meet palms' requirement.

Nursery trials on applying the various composted EFB on oil palm seedling have been reported.

Lim (1989) indicated that the use of the compost at 300-400 gm (air-dried) per polybag is able to offset about half the normal rate of fertiliser without adverse effects. This is due most probably to the high water holding capacity (can hold up to 1.5 times its dry weight), high cations exchange capacity and the reduction of fertiliser splash when they are applied as a surface mulch.

5. LIMITATIONS OF EMPTY FRUIT BUNCH (EFB) APPLICATION

Use of EFB for direct mulching sometimes can have problems and limitations. Firstly, if the stacking is not done properly would be caused by rhinoceros beetles breeding site. Secondly, EFB distribution in the oil palm fields poses seasonal difficulties especially on the clayey coastal soils than are easily puddled or flooded during rainy seasons. Thirdly, there is also the relatively high weight and volume of EFB in relation to nutrient content, which if decreased would make transport cost of the by-product from the mills to mulching site cheaper and further improve the economic benefits. Lastly, the operation of this application is quite labour cost intensive.

6. CONCLUSIONS

The EFB can either be used as fuel for generation of steam or power, or it can be returned to the field as mulch and supplementary fertilizer for oil palm. Based on the various research carried out, the application of EFB as mulch and supplementary fertilizer has shown an economically viable agricultural practices in managing plantation by-products by being a good sources of nutrients.

The importance of EFB application at time of planting and during maturity stage in increasing vegetative growth and yield is clearly demonstrated from the results carried out by various research stations (as presented in the paper). The significant responses obtained are largely due to the effect of EFB as an organic mulch.

However, there are some limitations on the use of fresh EFB for direct mulching as the EFB distribution in the field poses seasonal difficulties on the clayey coastal soils and relatively high weight and volume in relation to nutrient content as well as would cause the breeding site for rhino beetles if the stacking was not done properly.

The composted EFB with higher nutrient content and being less voluminous and lighter can be used for mulching oil palm at lower rate than presently practiced.

Finally, further work on direct application of EFB mulch such as studies on detailed microbial breakdown of EFB and changes to soil conditions and the utilization of composted EFB are required to greater optimization of benefit from EFB.

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