Empty Fruit Bunches Evaluation: Mulch in Plantation *vs.* Fuel for Electricity Generation

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INTRODUCTION

There are compelling reasons for supporting the use of empty fruit bunches (EFB) as a source of fuel for renewable energy (RE) power generation. Although the current use of EFB as a mulch does have financial benefits, there are better financial gains, with a number of other advantages when used as a fuel for RE power generation. The rapid depletion of fossil fuel needs an alternative replacement and most developed nations are pursuing the development of biomass as an alternative method of power generation. In Malaysia, fortunately the country has a ready source of biomass in EFB. It is conveniently collected and available for exploitation in all palm oil mills. All that needs to be done is to convert the energy in the fuel in the most efficient manner and the country is well on the way to pursue this most important and sustainable renewable source of energy for the future.

As the country has to meet the target of achieving 5% of its grid connected electrical energy from this source by the year 2005, it has to move fast. The main achievement will be the reduction in greenhouse gas emissions (GHG) if biomass-based RE power generation is used where there is a gain of substantial volume of carbon credits. This factor alone is a compelling reason to pursue. A deeper insight into the mechanism of EFB utilization with the financial analysis, if used as a mulch or fuel, is presented in this paper, without taking into account the capital investment involved in the RE power project.

METHODOLOGY

The methodology adopted in this paper is to compare the financial benefits in terms of fertilizer cost reduction when EFB is used as a fertilizer supplement with the revenue obtained from the sale of electricity generated and sold to Tenaga National Berhad from 1 t of EFB. All the economic benefits including an increased FFB yield of 15% and the income from its sale has been taken into account when EFB is utilized as a fertilizer supplement in this evaluation. For power generation by selecting a high boiler pressure and a low condenser pressure, thermodynamic calculations indicate high thermal efficiencies based on which the present evaluation is carried out.

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REVIEW

Evaluation as a Mulch

Mulching involves EFB being utilized as a fertilizer substitute for the palms when distributed evenly in the field. There are three components to the cost when EFB is used as a mulch (Gurmit *et al.*, 1999). They are:

- EFB loading cost. Usually the EFB leaving the mill stripper are conveyed to a hopper, some distance away;
- transportation from mill to the estate. From the hoppers, empty lorries/ trailers can load the EFB for transporting them to designated fields in the estate; and
- field distribution. The EFB, heaped along the field roads, are loaded onto mini tractor-mounted trailer manually or mechanically.

The rate of EFB application. The following application rates can be used as a guide:

- circle mulching of newly planted and immature palms (15 to 25 t/ha/yr);
- mature palms on coastal soils (25 to 40 t/ha/yr); and
- mature palm on inland soils (35 to 70 t/ha/yr).

In order to obtain the best benefits from application of EFB in the field, inorganic supplements are also required. They are given for immature and mature palms in *Tables 1* and *2* (Gurmit *et al.*, 1999).

However, there are innumerable problems associated with the EFB application as a mulch in the estates. They are:

- distance of the field from the mill;
- unfavourable field conditions like hilly areas, steep terrain, soft ground *etc.*, which hinder deployment of vehicles;
- heavy traffic causing damage to field roads and harvesting paths requiring frequent upgrading which can be costly;
- field inaccessibility to light vehicles during rainy months;
- mulching field close to worker's quarters can encourage breeding of flies. When placed in heaps at road sides besides causing breeding of rhinoceros beetle, there is leaching of potassium returned from the heaps;
- insufficient vehicles during peak cropping months due to vehicle breakdowns causes total neglect of EFB evacuation as the vehicles are given priority for FFB evacuation from the field; and
- in the case of government land schemes, the settlers are not given the benefit to mulch their field.

TABLE 1. APPLICATION RATES OF INORGANIC FERTILIZERS ON IMMATURE PALM

Immature palms: inland soils		Immature palms: coastal soils	
Inorganic fertilizer	Application rate (kg/ha)	Inorganic fertilizer	Application rate (kg/ha)
Ammonium sulphate	148	Urea	102
		Rock phosphate	34

TABLE 2. APPLICATION RATES OF INORGANIC FERTILIZERS ON MATURE PALMS

Mature palms: inland soils		Mature palms: coastal soils	
Inorganic fertilizer	Application rate (kg/ha)	Inorganic fertilizer	Application rate (kg/ha)
Ammonium sulphate	148-144	Urea	102-136
Rock phosphate	0-222	Rock phosphate	34-136
Muriate of potash	0-148		

Further, there are a number of millers in the country, who do not own plantations for EFB mulching and they have to bear the burden of transport cost for EFB evacuation. Detailed data (Hoong and Nadaraja, 1988) after several years of field trials by Sabah Land Development Boar (SLDB) and that of Kumpulan Guthrie and other plantation groups were obtained. Currently, most of the EFB are used as mulch in plantations almost wholly replacing incineration, which is now confined to only a few mills. The analyses carried out on EFB indicates the following average composition (*Table 3*).

The usual application rate of EFB is 35 to 70 t/ha. The EFB trials carried out in SLDB evaluated the nutrient content in 1 t of EFB to be as given in *Table 4*.

This indicates that the financial value of 1 t EFB as a fertilizer is RM 11.47 based on the latest price of fertilizer as at December 2002.

As the nutrient contents are, however, variable as can be seen

TABLE 3. NUTRIENT CONTENT OF EMPTY FRUIT BUNCHES

Composition as a percentage of dry matter				
Nitrogen (N)	Phosphorous (P)	Potassium (K)	Magnesium (Mg)	Calcium (Ca)
0.44	0.144	2.24	0.36	0.36

TABLE 4. FERTILIZER CONTENT OF EMPTY FRUIT BUNCHES (EFB) (1 t)

Component	Equivalent quantity of nutrient (kg)	2 Dec price of fertilizers (RM/t)	2 Dec price of fertilizers (RM)	Actual nutrient value as fertilizer(RM)
Urea	3.8	540-580	0.54	2.05
Rock phosphate	3.9	545	0.55	2.15
Muriate of potash	18.0	230-250	0.23	4.14
Kieserite	9.2	340-400	0.34	3.13
Total value as fertilizer/t EFB				11.47

TABLE 5. NUTRIENT CONTENT OF EMPTY FRUIT BUNCHES (EFB) (1t) AND ITS FERTILIZER VALUE

Component	Equivalent quantity of nutrient (kg)	2 Dec price of fertilizers (RM/t)	2 Dec price of fertilizers (RM)	Actual nutrient value as fertilizer (RM)
Urea	3.0	540-580	0.54	1.62
Rock phosphate	0.6	545	0.55	0.33
Muriate of potash	12.0	230-250	0.23	2.76
Kieserite	2.0	340-400	0.34	0.68
Total value as fertilizer/t EFB				5.39

from the findings of Loong *et al*. (1987), the nutrient value obtained can be lower. They are given in *Table 5*.

But in both cases (*Tables 4* and *5*) they have not taken into consideration the 15% to 20% increases in yield as claimed by some researchers. They are considered in detail later in this paper.

Apart from providing nutrients to the palms through slow release process, EFB as an organic mulch is known to improve the structure and moisture retention ability of the soil as well as stimulate root growth for better exploitation of nutrients and water. Its mulching effect would minimize leaching and soil erosion problems especially on steep lands under intense rainfall.

Mulching is usually carried out in schemes within 5 km radius from the mills and is not available for the whole estate. Additional nutrition also will be needed as nutrition supplement as EFB by itself will not be able to satisfy the full fertilizer requirement of the palms. Generally, the nutrients supplied by two rates of mulching are given in *Table 6*.

Other plantation trials. In *Tables 7* and *8*, the beneficial effects of EFB mulching at 25 t/ha/yr are computed.

The prices of most of the inorganic fertilizer components except for MOP have now been increased as shown in *Table 9*.

Other benefits and cost factors. The application of EFB mulch in oil palm plantation is reported to contribute towards other benefits and cost factors as shown in *Table 10*. The values are given for a hectare with a FFB yield of 22 t/ha (*Table 10*).

It is important to note that the figures shown in *Table 10* were obtained under controlled conditions and close monitoring. In reality, it is very much doubtful whether it is possible to achieve an even distribution of EFB in the field consistently. Besides that, the EFB generated by the mill can only cover a small area of the plantation due to the high transport cost involved in making it available to all the palms. During high crop periods, the tendency is to give priority to the FFB rather than the EFB with the result that EFB evacuation and not mulching gets the priority. These are points to ponder when undue importance is given to the benefits of EFB mulching.

Evaluation of Empty Fruit Bunch (EFB) as a Fuel for Power Generation

At 65% moisture content, EFB has a calorific value of 6028 kJ/kg (lower or net CV). The heat content of 1 t EFB = 6028 x 1000 kJ = 6 028 000 kJ.

A boiler generating steam at 42 bar absolute (bara) with a superheat temperature of 500°C

TABLE 6. VALUE OF EMPTY FRUIT BUNCHES (EFB) COMPARED TO INORGANIC FERTILIZER

EFB (t/ha)	Mulching application rate (kg/ha)				Value of nutrient (RM/ha)
	Urea	MOP	Rock phosphate	Kieserite	
40	152	702	156	368	601.60
70	266	1260	273	644	1 052.8

TABLE 7. POTENTIAL SAVINGS FROM EMPTY FRUIT BUNCHES (EFB) MULCHING IN PLANTATIONS (ha/yr)

	Nitrogen	Phosphorous	Potassium	Magnesium	Savings (RM)
EFB (25 t/ha)	80	10	241	18	**392** based on palm oil price of 1050 & kernel price of 700
Fertilizer type	S/A N =21%	CIRP P_2O_5 = 35%	MOP K_2O =60%	Kieserite MgO = 26%	
Equivalent (kg/ha)	381	64	484	115	
Monetary value (RM)	153	17	187	35	
Increase by 50% to cater for current prices of palm products say RM 1 575					**588**

TABLE 8. COST OF INORGANIC FERTILIZERS USED FOR THE ABOVE COMPUTATION AS AT 1989

Sulphate of ammonia (S/A)	CIRP (Rock phosphate)	Muriate of potash	Kieserite
RM 401	RM 61	RM 386	RM 298

TABLE 9. COST OF INORGANIC FERTILIZERS AS AT DECEMBER 2002

Sulphate of ammonia (S/A)	CIRP (Rock phosphate)	Muriate of potash	Kieserite
RM 540-580	RM 545	RM 230-RM 250	RM 340-RM 400

and a condensing turbine operating in a pressure range between 42 bara and 0.035 bara can give a Rankine efficiency of 39.8%. The actual thermal efficiency generally is 84% of this. Even if it is assumed the actual cycle efficiency to be 80% of the Rankine efficiency, the thermal efficiency is 32%. However, in this analysis, the overall thermal efficiency is assumed to be only 25%. Thus, 1 t of EFB with 65% moisture should deliver 6 028 000 x 0.25 kJ = 1 507 000 kJ of energy.

1 507 000 kJ = 1 507 000 / 3600 kWhr = 418.6 kWhr (*i.e.* units of electricity).

Assuming the minimum price offered by TNB for a unit of electricity is 17 sen (still under negotiation). The gross income will be. RM 71.16.

Allowing 30% operational and maintenance cost, the net revenue will be RM 49.81.

ANALYSIS

One tonne of EFB when used as a mulch was found to be RM 14.40 (*Table 10*). This figure includes all the benefits as a fertilizer as well as the increased FFB yields resulting from using EFB to supplement fertilizer cost.

In the case of power generation using EFB as a fuel, even though the thermodynamic calculations indicate a Rankine efficiency of 39.8%, in this exercise only a conservative figure of 25% was considered for power output. In addition, the TNB tariff used for this analysis was 17 sen but there is a possibility this might be raised based on the request from MPOB in which case the net gain would be substantially higher than what is shown in this exercise.

DISCUSSION AND CONCLUSION

The economical value of 1 t EFB as a mulch is only RM 14.40, while as a fuel for power generation is RM 49.81. The returns are 3.5 times! - indicating beyond reasonable doubt there is significant financial gain in using EFB for power generation. The gain would be substantially higher if the tariff for electricity is 20 sen instead of the 17 sen used for this computation. Besides the financial gain, the saving in fossil fuel and possibly the use of carbon credit will add favourably justifying its use for RE power generation. In

TABLE 10. COST FACTORS ASSOCIATED WITH EMPTY FRUIT BUNCHES (EFB) MULCH

	Products	Quantity	Value in (RM)
(a) Additional yield over normal estate manuring	FFB yield @15% x 22 t	3.3 t	-
	Corresponding gain in oil	0.66 t	-
	Corresponding gain in kernel	0.20 t	-
(b) Additional revenue	Gross value of oil @ RM 850/t	0.66 t	561.00
	Gross value of kernel @ RM 450/t	0.20 t	90.00
	Total gross value of products		**651.00**
(c) Mulching cost supplementary NPK	EFB @37 t x RM 5/t	37 t	185
	Ammonium sulphate	136 kg	37.40
	Rock phosphate	204 kg	41.80
	Muriate of potash	136 kg	47.60
	Application cost-3 rounds	RM 5/round	15.00
	Total mulching cost		**326.80**
(d) Normal estate manuring cost (NEM)	Ammonium sulphate: 408 kg	RM 275/t	112.20
	Rock phosphate: 204 kg	RM 205/t	41.80
	Muriate of potash: 408	RM 350/t	142.80
	Kieserite: 136 kg	RM 300/t	40.80
	Borate 48: 14 kg	RM 260/t	17.60
	Application cost-7 rounds	RM 5/round	35.00
	Total cost		**390.20**
(e) Savings over NEM	(d -c)	390.20-326.80	**63.40**
(f) Additional cost	Harvesting, collection & transport @RM 27/t FFB	3.3 t	89.10
	Processing charge @ RM 28/t FFB	3.3 t	92.40
	Total		**181.50**
(g) Net returns from 37 t of EFB applied to 1 t	(b + e -f)		**532.90**
(h) Net returns from **1 t EFB** when used as mulch	(g) / 37		**14.40**

Sources: Gurmit *et al.* (1999); Chan (1996).

addition, Malaysia will be seen to be taking the first solid step towards fulfilling its global obligation in reducing GHG emissions that by itself is a noble deed worth considering.

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