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

N Ravi Menon*

SYNOPSIS

There are a number of compelling reasons for supporting the use of empty fruit bunches (EFB) as a source of fuel for renewable energy (RE) power generation in Malaysia. Although the current use of EFB as a mulch does have financial benefits, there are many more avenues for better financial gains as well as a number of other advantages to be derived by using EFB as a fuel for RE power generation. The rapid depletion of fossil fuel requires an alternative. Most developed nations are presently seriously pursuing the development of biomass as an alternative method of power generation. In Malaysia fortunately, there is always a ready source of biomass in the form of EFB that can be easily collected and made available for exploitation in the palm oil mills. All that needs to be done is to convert the energy already existent in the fuel in the most efficient manner and the country will be well on its way to pursue this vital, sustainable and renewable source of energy of the future.

As the country is required to meet the target of achieving 5% of the grid connected electrical energy from this source by the year 2005, we have to act and act fast at that. Our main achievement will be the reduction in greenhouse gas (GHG) emissions if biomass-based RE power generation is utilized as this will invariably result in substantial gain in the volume of carbon credits. A deeper insight into the mechanism of the utilization of EFB as a mulch or fuel as well as the financial implications involved is presented elsewhere in this paper.

* *Malaysian Palm Oil Board,*
P.O. Box 10620,
50720 Kuala Lumpur, Malaysia.

EVALUATION AS A MULCH

Mulching involves the utilization of EFB as a fertilizer substitute for the palms when they are 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 the 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 on to mini tractors manually or mechanically.

THE RATE OF EMPTY FRUIT BUNCHES (EFB) APPLICATION

The following application rates can be used as a guide:

- circle mulching of newly planted and immature palms - 15 to 25 t $ha^{-1}yr^{-1}$;
- mature palms on coastal soils – 25 to 40 t $ha^{-1}yr^{-1}$; and

- mature palm on inland soils – 35 to 70 t ha^{-1}yr^{-1}.

In order to derive maximum benefits from the application of EFB in the field, inorganic supplements are also required. These have been tabulated separately, for immature and mature palms, in *Tables 1* and *2* (Gurmit *et al.*, 1999).

TABLE 1. APPLICATION RATES OF INORGANIC FERTILIZERS ON IMMATURE PALM

Immature palms: inland soils		Immature palms: coastal soils	
Inorganic fertilizer	Application rate (kg ha^{-1})	Inorganic fertilizer	Application rate (kg ha^{-1})
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^{-1})	Inorganic fertilizer	Application rate (kg ha^{-1})
Ammonium sulphate	148 – 444	Urea	102 – 136
Rock phosphate	0 – 222	Rock phosphate	34 – 136
Muriate of potash	0 – 148		

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 the deployment of vehicles;
- heavy traffic causing damage to field roads and harvesting paths which require frequent upgrading will lead to additional costs;
- field inaccessibility to light vehicles during rainy months;
- mulching field located close to worker's quarters can encourage the breeding of flies. When placed in heaps along road sides, it will lead to the breeding of rhinoceros beetles as well as the leaching of potassium that can otherwise be recouped from the heaps;
- unavailability of sufficient vehicles during peak cropping months due to vehicle breakdowns resulting in the neglect of EFB evacuation as the vehicles are normally given precedence over FFB evacuation from the fields; and
- in the case of government land schemes, the settlers do not enjoy the benefits of mulching their field.

Furthermore, 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 transportation cost for EFB evacuation. Detailed data (Hoong and Nadaraja, 1988) involving several years of field trials by the Sabah Land Development Board (SLDB) and that of Kumpulan Guthrie and other plantation groups are presented in *Table 3*. 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:

The usual application rate of EFB is 35 to 70 t ha^{-1}. The EFB trials carried out by SLDB have 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 of EFB as a fertilizer is RM 11.47 based on the latest price of fertilizer as at December 2002.

As the nutrient contents are variable as can be seen from the findings of Loong *et al.* (1987), the nutrient value thus obtained can be lower (*Table 5*).

Both *Tables 4* and *5* have not taken into consideration the 15% to 20% increase in yield as is claimed by some researchers. They are examined in detail later on in this paper.

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

Mulching is usually carried out in schemes within a 5 km radius from the mills and is not available for the whole estate. Additional nutrition will be needed as a supplement since EFB, by itself, will not be able to satisfy the full fertilizer requirements

TABLE 3. NUTRIENT CONTENT OF EMPTY FRUIT BUNCHES

Composition as a percentage to 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 ONE TONNE EMPTY FRUIT BUNCHES

Component	Equivalent quantity of nutrient (kg)	2 Dec price of fertilizers in (RM t^{-1})	2 Dec price of fertilizers (RM kg^{-1})	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 ONE TONNE EFB AND ITS FERTILIZER VALUE

Component	Equivalent quantity of nutrient (kg)	2 Dec price of fertilizers in (RM t^{-1})	2 Dec price of fertilizers (RM kg^{-1})	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

TABLE 6. VALUE OF EFB COMPARED TO INORGANIC FERTILIZER

EFB t ha^{-1}	Mulching application rate (kg ha^{-1})				Value of nutrient (RM ha^{-1})
	Urea	MOP	Rock phosphate	Kieserite	
40	152	702	156	368	601.60
70	266	1 260	273	644	1 052.8

TABLE 7. POTENTIAL SAVINGS FROM EFB MULCHING IN PLANTATIONS (ha yr^{-1})

	Nitrogen	Phosphorous	Potassium	Magnesium	Savings RM
EFB 25 t ha^{-1}	80	10	241	18	392
Fertilizer type	S/A N = 21%	CIRP P_2O_5 = 35%	MOP K_2O = 60%	Kieserite MgO = 26%	Based on palm oil price of 1050 and kernel price of 700
Equivalent kg ha^{-1}	381	64	484	115	
Monetary value (RM)	153	17	187	35	
Increase by 50% to cater for current prices of palm products approximately valued at RM 1575					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) as urea	CIRP(Rock phosphate)	Muriate of potash	Kieserite
RM 540 – RM 580	RM 545	RM 230 – RM 250	RM 340 – RM 400

of the palms. The nutrients supplied by two different rates of mulching are given in *Table 6*.

Other Plantation Trials

The beneficial effects of EFB mulching at 25 t ha^{-1} yr^{-1} have been computed in *Tables 7* and *8*.

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

OTHER BENEFITS AND COST FACTORS

The application of EFB mulch in oil palm plantations is reported to contribute towards other benefits and costing factors as follows: These values are based on a hectare with a FFB yield of 22 t ha^{-1} (*Table 10*).

It is important to note that the figures in *Table* 10 were obtained under controlled conditions and close monitoring situations. In reality, however, 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

Continued on page 19

Continued from page 14

TABLE 10. COST FACTORS ASSOCIATED WITH 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^{-1}	0.66 t	561.00
	Gross value of kernel @ RM 450 t^{-1}	0.20 t	90.00
	Total gross value of products	–	**651.00**
(c) Mulching cost Supplementary NPK	EFB @37 t x RM 5 t^{-1}	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^{-1}	112.20
	Rock phosphate: 204 kg	RM 205 t^{-1}	41.80
	Muriate of potash: 408	RM 350 t^{-1}	142.80
	Kieserite: 136 kg	RM 300 t^{-1}	40.80
	Borate 48: 14 kg	RM 260 t^{-1}	17.60
	Application cost - 7 rounds	RM 5/round	35.00
	Total cost	–	**390.20**
(e) Savings over NEM cost	(d –c)	390.20 – 326.80	**63.40**
(f) Additional cost	Harvesting, collection & transport @ RM 27 t^{-1} FFB	3.3 t	89.10
	Processing charge @ RM 28 t^{-1} 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).

area of the plantation due to the high transportation costs 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, thus resulting in the EFB evacuation at the expense of mulching. These are points to ponder as undue importance is being given to the benefits of EFB mulching.

EVALUATION OF EMPTY FRUIT BUNCHES (EFB) AS A FUEL FOR POWER GENERATION

At 65% moisture content, EFB has a calorific value of 6028 kJ kg^{-1} (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 and a condensing turbine operating between a pressure range between 42 bara and 0.035 bara can give a Rankine efficiency of 39.8%. The actual thermal efficiency, however, is generally about 84% of this. Even if it is assumed that the actual cycle efficiency is only 80% of the Rankine efficiency, the thermal efficiency should be 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 that 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 for a 30% operational and maintenance cost.

The net revenue to be generated will be RM 49.81.

However, 1 t of EFB, when used as a mulch, was found to berated at RM 14.40 (*Table 10*).

This is a very conservative figure and the actual net gain could be substantially higher more if the tariff, now under negotiation, is raised.

CONCLUSION

The economic value of 1 t EFB as a mulch is only RM 14.40, while as a fuel for power generation, it is RM 49.81. The returns which are 3.5 times higher do indicate, beyond reasonable doubt that there will be a significant financial gain from using EFB for power generation. This gain will be substantially higher if the tariff for electricity is based on 20 sen instead of the 17 sen as has been used for this computation. Besides the financial gain, the saving in fossil fuel and the possible use of carbon credit will further justify the use of EFB for RE power generation. In addition, Malaysia will be seen to be taking the first bold step towards fulfilling its global obligation of reducing GHG emissions. Undoubtedly, this factor alone is worth serious consideration.

ACKNOWLEDGEMENT

The author would like to express his gratitude for the technical assistance accorded by Dr Chan Kook Weng, Dr Rajanaidu and also the encouragement given by the Director-General of MPOB.

REFERENCES

CHAN, K W (1996). Economics of environmental protection and sustainable crop management practices in the oil palm industry. *Proc. of the* 1996 PORIM *International Palm Oil Conference*. PORIM, Bangi. p.181.

CHAN, K W; CHOW, M C; MA, A N and YUSOF BASIRON (2002). The global challenge of GHG emission on carbon reduction: palm oil industry. Paper presented at the 2002 National Seminar on Palm Oil Milling, Refining Technology, Quality and Environment. MPOB, 19-20 August 2002, Magellan Sutera Hotel, Kota Kinabalu, Sabah. 12 pp.

GURMIT, S; KOW, D L; LEE, K H; LIM, K C and LOONG, S G (1999). Empty fruit bunches as mulch. *The Oil Palm and the Environment – A Malaysian Perspective.* (Gurmit, S; Lim, K H; Teo, L; David and L K eds.). Kuala Lumpur. p. 171-181

HOONG, H W and NADARAJA, M N (1988). Mulching of empty fruit bunches of oil palm in S.L.D.B. *SLDB/PORIM Workshop on Palm Oil Milling Technology*. Kota Kinabalu, Sabah. p.38-50.

LOONG, S G; MOHD NAZEEB; LETCHUMANAN and WOOD, B J (1990). Under planting as a means to shorten the non-productive period of oil palm. *Proc. of the* 1989 PORIM *Palm Oil Conference Agricultural Conference* (Jalani, B S; Zin, Z Z; Paranjothy, K; Ariffin, D; Rajanaidu, N; Cheah, S C; Mohd Basri, W; Henson, I E and Mohd Tayeb, D eds). PORIM, Bangi. p. 159-168. ■