SYSTEM OF PRODUCTION OF PALM OIL

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Martin (1981) provides a detailed energy analysis of production of palm oil including plantations and processing. He includes the fuels embodied in equipment, fertilizer, etc. In order to complete the analysis and make it appropriate for Bahia, Brazil, Table 1 was prepared. It includes the environmental embodied energies in rain used in transpiration, those in geologic work in fertilizer, and the embodied energy in human service as produced in Bahia. A price of $0.35/kg given by Martin for Latin America for 1981 was used pending data on local price in Bahia. Embodied energy in services was obtained using energy/dollar ratio for Brazil.

The transformation ratio calculated from the summed inputs was 9.3 E4 and is higher than for motor fuels and in the range appropriate for foods which are more valuable per unit than fuels. The net energy yield ratio calculated with all purchased inputs including fertilizer was 1.06. Producing oil provides a needed product but does not generate much new net energy the way using fossil fuel does.

If the yield ratio includes only the direct and indirect fuel inputs the ratio is 3.5, which means that the palm oil is a reasonable way of getting diesel fuel when the current fossil fuel sources with higher net energies are gone.

The palm oil system is diagrammed in Figure 1.

LITERATURE CITED

Martin, G. 1981. Energy balance of oil palm growing: An approach. Oleagineaux, 36 (6 June):280-284.

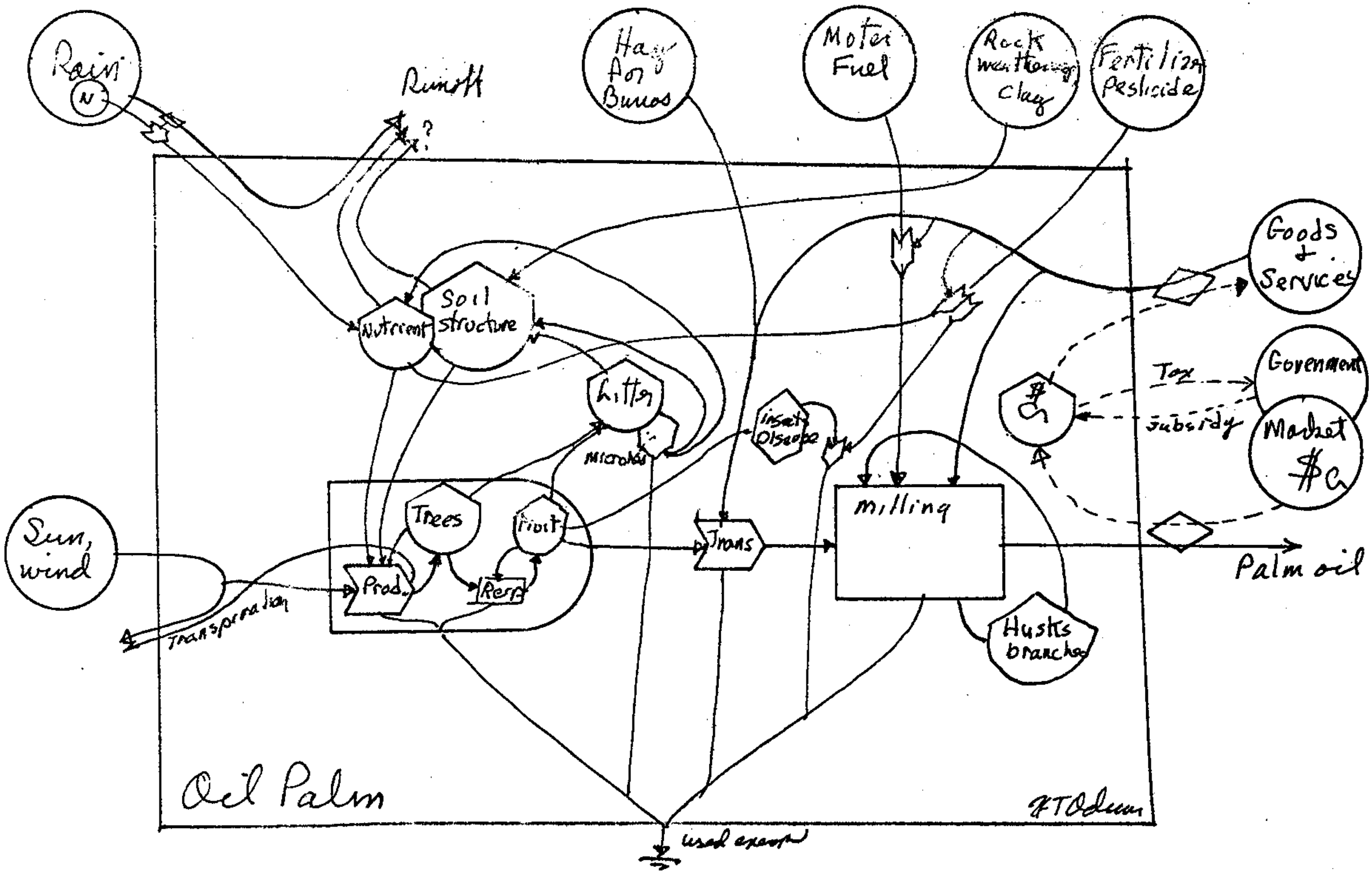

Figure 1. Energy diagram of system of oil palm in Bahia, Brazil.

Table 1. Energy flows in system of production and extraction of oil from African oil palm, per hectare.* Data modified from Martin (1981).

Foot-note	Item	Actual Energy J, g, or $ per yr	ETR SE joules per J, or per $	Embodied Energy E13 SEJ
1	Direct solar energy	5.35 E13	1	5.4
2	Water transpired	6.75 E10 J	1.5 E4	101.
3	Nitrogen	57 E3 g N	4.2 E9/g	24.
4	Potassium	104 E3 g K	3.2 E9/g	33.
5	Phosphate	15 E3 g P	2.0 E10/g	30.
6	Magnesium (59 E3 g MgO)	19 E3 g Mg		
7	Electricity used	1.43 E9 J	1.5 E5/J	21.5
8	Fuels used directly	8.4 E9 J	6.6 E4/J	55.
9	Fuels involved in capital equipment	46 E9 J	6.6 E4/J	303.
10	Fuels in fertilizers and other processes	6.8 E9 J	6.6 E4/J	45.
11	Services in $(1980)/kg	3.3 E3 $	6.9 E12/$	1195.
12	Total inputs not double counting			1814
13	Yield of oils	195.5 E9 J		
14			9.3 E4	
15	Net energy yield ratio		1.06	
16	Liquid fuel produced over liquid fuel used		3.5	

Footnotes to Table 1

* Data from Martin (1981) from plantations and extraction mills in Malaysia.

1,2 Solar energy and transpired water were appropriate for Bahia, Brazil.

3-6 Fertilizer inputs from Martin (1981).

7 Electrical energy

(400 KWH/ha)(860 kcal/KWH)(4186 J/kcal) = 1.43 E9 J/ha/y

8-10 Direct and indirect fuel use from Martin (1981)

Services estimated from costs

Goods and services based on oil price in Bahia, Brazil, 1980, and Brazil's energy dollar ratio from Odum and Odum (1981)

Palm oil price (1980$), $.35/kg

(.35/kg)(4950 kg/ha) = $1732/ha/y

($1732/ha)(6.9 E12 SEJ/$1980) = 1.195 E16 SEJ

1980 price, 2000 Cr/ton (Cepec, 1983)
saw seeds

(4950 kg/ha)(0.036/kg)

12 Omitting direct solar energy because it contributes to item 2.

13 Yields (Martin, 1981) palm oil, 183 E6 k J/ha from 4620 kg plus 12.5 E6 k J/ha from palm 330 kg kernal oil. (9.5 kcal/kg palm oil and 9.07 kcal/g palm kernal oil.

14 $$\text{ETR} = \frac{\text{Total inputs in SEJ}}{\text{Yield in J}} = \frac{\text{1814 E13 SEJ}}{\text{1955 E9 J}} = \text{9.3 E4}$$

ETR is similar to that for diesel oil and this is a confirmation of the solar equivalents for oil.

15 Net energy yield ratio including all inputs as feedbacks except rain

$$\frac{\text{1814 E13 SEJ}}{\text{1708 E13 SEJ}} = 1.06$$

16 Net fuel including 8% of Brazilian services derived from fuel.

$$\frac{\text{1814 E13 SEJ}}{(21.5+55+303+45+(0.08)(1195))}$$

$$\frac{1814}{520} = 3.5$$