The Palm Oil Industry in West Malaysia

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Foreword

Within the past 10 years, palm oil has gained prominence within the world edible oil economy, acquiring each year a progressively larger portion of total edible oil trade—from 6 percent in 1966 to nearly 14 percent in 1976, with projections reaching 20 percent by 1980.

West Malaysia far exceeds other major producers in volume of palm oil exported. Basic research, improved processing techniques, and ideal climate conditions have made palm oil the second largest export earner for Malaysia.

By 1980, West Malaysia probably will account for more than two-thirds of world palm oil production. A steady rise from 1976's level of 1.3 million tons is forecast, with outturns reaching about 2 million tons by 1980 and 2.6 million tons by 1985.

Almost all of this palm oil will be available for export. Less than 3 percent of production is expected to be retained for domestic consumption.

Scheduled additions to oil palm area and planned processing improvements in Malaysia leave no doubt that the Government intends to maintain Malaysia as the world leader in production, technology, and distribution of palm oil.

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Introduction

According to recent archaeological findings, as early as 2700 B.C. several earthen vases were placed into the sepulchral vault of an Egyptian tomb to serve as provisions for the deceased. One vase held a light brown, considerably oxidized granular material proven under examination to contain palmitic acid mixed with less than 51 percent tripalmitin and oleodipalmitin triglycerides. The substance—palm oil.

Thus commences the recorded history of a commodity whose useful applications have ranged from a hand cream and medicine in 18th century Britain to a lubricant in the modern tinplate manufacturing industry in the United States.

Most palm oil today is consumed as edible oil, especially in shortening and margarine, while advances in fractionation methods have expanded its use in the manufacture of salad oils.

Throughout the first half of this century, Africa led the world in production and export of palm oil, with Nigeria and Zaire (formerly Congo) in front. But growing commercial planting of the oil palm species *Elaeis guineensis* in Southeast Asia during the first half of this century spelled the end of Africa's dominance as a net world exporter of palm oil. By 1966, Malaysia and Indonesia together had surpassed Africa's total palm oil exports, even though Nigeria alone (consuming most of its output) produced more that year than Malaysia and Indonesia combined.

In the world palm oil arena, the spotlight is now on West Malaysia, which delivers 40 percent of world palm oil production and 65 percent of world palm oil exports. And all forecasts presage improvement of these levels.

Production Area

Until 1965, oil palm area in West Malaysia grew steadily but marginally. Then an expanded number of private plantations, projects (or schemes) of the Federal Land Development Authority (FELDA), State development projects, and accelerated expansion of oil palm area assumed major importance in agricultural development and diversification under the First and Second Malaysian Plans (1966-75).

Alarmed by falling rubber prices in the 1960's, Malaysian rubber producers embarked on a project of agricultural diversification intended to ease dependence upon rubber sales for export earnings. In 1961, private rubber estates in West Malaysia comprised 785,000 hectares of rubber trees; by 1971 that number had dropped to 631,000 hectares. Most of this 154,000-hectare reduction was replanted to oil palm. FELDA supervised establishment of many oil palm schemes during the same period, helping boost oil palm area from approximately 57,000 hectares in 1961 to 311,000 hectares in 1971—75,000 hectares added by FELDA.

During the 1961-71 period, then, roughly 50-60 percent of new oil palm plantings replaced rubber stands. As a result, total rubber area in West Malaysia increased by only 2 percent—from 1.61 million hectares in 1961 to 1.72 million hectares in 1972—since new smallholder rubber planting during that period was nearly balanced by substitution of oil palms for rubber trees.

Malaysian export earnings from rubber fell from a 1966 level of U.S. $589.6 million, or a 38.3 percent share of total Malaysian exports that year, to $584.1 million—a 29.1 percent share—in 1971. This represented, for rubber, a nearly 10 percent drop in share of total Malaysian export earnings within 5 years.

Palm oil export earnings moved from $48 million in 1966, or 3.1 percent of total export earnings, to $152.2 million, or 7.6 percent in 1971.

The largest group of oil palms was planted between 1970 and 1975 (Table 9), and will attain peak production in 1980-85. Planned area expansion

Table 1.–WEST MALAYSIA: RUBBER AND OIL PALM AREA AND EXPORT EARNINGS

Year	Oil Palm			Rubber		
	Area	Export earnings	Total export earnings	Area	Export earnings	Total export earnings
	1,000 ha.	*Mil. U.S.$*	*Percent*	*1,000 ha.*	*Mil. U.S.$*	*Percent*
1961	57	11.2	–	1,675	647.0	45.0
1966	123	48.0	3.1	1,774	589.6	38.3
1971	311	152.2	7.6	1,723	584.1	29.1
1976	590	443.5	9.4	1,659	1,192.2	25.2

Sources: Unless otherwise indicated, area figures are from publications of the Malaysian Oil Palm Growers Council and the Malaysian Rubber Bureau. Earnings data are drawn from International Financial Statistics, an International Monetary Fund publication.

after 1976 drops considerably from levels maintained in previous years.

Johore, the southernmost peninsular State, claims the most oil palm area–197,361 hectares, or 34 percent of West Malaysia's total. The largest State in West Malaysia, Pahang, follows with 31 percent. Johore, Pahang, and Selangor (containing the capital city, Kuala Lumpur) together comprise 78 percent of peninsular Malaysia's oil palm area, and supply approximately one-third of the world's palm oil.

Presently, 260,000 hectares of oil palm are managed by either FELDA or one of several State land development boards. Roughly 46 percent of West Malaysia's oil palm stands exist under the aegis of such Government land development agencies.

FELDA has been a major element in Malaysia's burgeoning palm oil industry. An agency of the Malaysian Government, FELDA invites application from Malaysian citizens who desire to resettle on a FELDA scheme with their families and work as smallholders. FELDA resettled 36,000 families on 250,000 hectares of either oil palm or rubber during the period 1956-75.

FELDA's budget comprises grants and loans from the Malaysian Government (89 percent), loans from the International Bank for Reconstruction and Development (IBRD) and Asian Development Bank (ADB) (7 percent), and general grants and loans from smaller domestic and international cooperation funds (4 percent). Costs of clearing jungle, constructing houses, hospitals, schools, and building roads are borne by FELDA. The smallholder shoulders responsibility for harvesting and maintaining his assigned plot of land, sells his fruit bunches to FELDA processing mills, and gives a portion of his gross revenue to FELDA as a loan payment for his land. Eventually harvesters acquire ownership of that land.

Production Methods

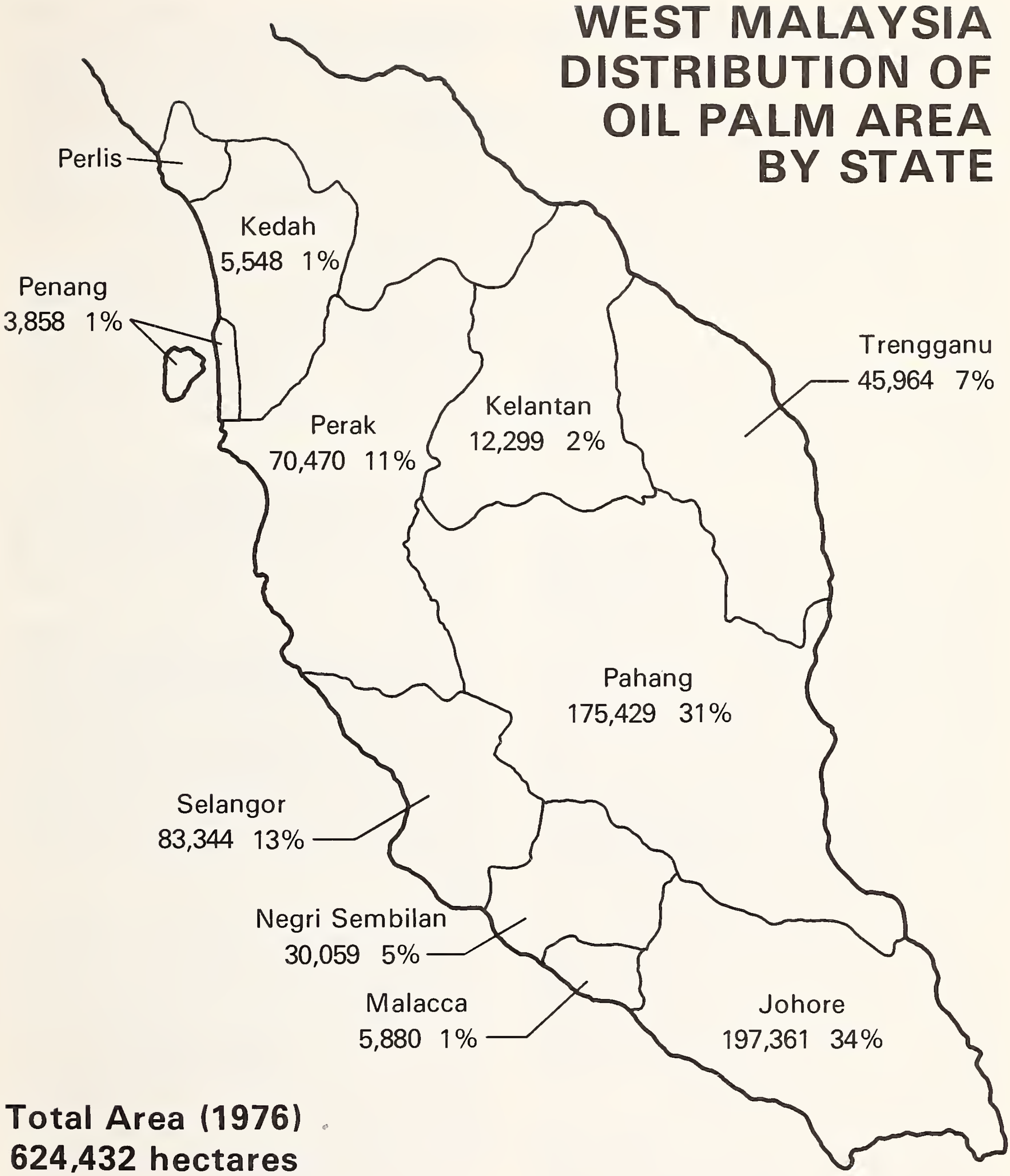
The well-leached laterite soils of peninsular Malaysia introduce a considerable nutrient-loss factor into oil palm cultivation, requiring careful application of fertilizers during both immature and mature stages of plant development. On sandy inland soils fertilizer can comprise over half of the upkeep costs for mature stands. A premium attaches to balanced application of fertilizer types according to particular soil conditions and climate factors.

Potassium, nitrogen, and magnesium are the most crucial components in oil palm nutrient treatment. Muriate of potash commonly supplies potassium needs, the proper amount and rate of application depending on the potassium status of the soil. Urea and ammonium sulphate contribute nitrogen, with urea likely to be used more widely, because it sustains slightly smaller leaching losses on peninsular soils (and induces less leaching of other nutrients) than ammonium sulphate. Kieserite and magnesium limestone constitute the primary sources of magnesium. Yields are depressed if magnesium and potassium are not applied in balance.

Considerable attention presently centers on wider use of nitrogen-fixing legumes as ground cover on oil palm stands and timing of fertilizer application to avoid monsoon seasons in late spring and autumn when soil leaching is most pronounced. Malaysian soil scientists more recently have focused on micronutrient deficiencies of the oil palm–notably copper and boron.

Prior to planting seedlings, application of herbicides such as glyphosate help control *lalang* and other harmful wild grasses. Postemergent application of paraquat in a 10-foot circle around oil palm trees clears a space at the base of palms, facilitating retrieval of loose fruits after fresh fruit bunches have fallen to the ground. This aid notwithstanding, collection of loose fruits often demands one-third of a harvester's working time.

Foremost among oil palm pests, *Rhinocerous* beetles bore into young oil palm plants, disturbing cambium structure and interfering with normal plant growth. Rats and squirrels clamber up mature trees and nibble fruits down to half their normal size. These pests are counteracted with various pesticides,



Sources: Area distribution data by Malaysian Oil Palm Growers Council.

which cause some reduction in the natural enemy population. Oil palm pest control therefore requires a balance between natural enemy maintenance and chemical intervention of a selective, fast-fading nature.

Ganoderma, a pathogen that causes dry basal rot in oil palms, presents the greatest disease threat to oil palms in West Malaysia. This fungus produces spores that attack a palm either through roots by contact with adjacent diseased roots or stumps, or through the air onto open wounds such as freshly cut frond bases. Subsequent to infection *Ganoderma* eventually cuts off water and mineral nutrients to aerial sections of the tree.

Fungicides help stem the spread of *Ganoderma,* which is most prominent in coastal areas where oil palms have replaced coconut stands. The considerable time required for tree surgery, a traditionally reliable treatment for trees infected with *Ganoderma,* precludes its widespread adoption for abating the disease.

A crucial factor in producing high-quality palm oil is harvesting care. Harvesters normally utilize a pole with pruning hooks or blades attached to the tip. They first chop away fonds supporting the fresh fruit bunch to expose the bunch stem. They then hack at the stem until it splits, allowing the bunch to fall.

Impact with the ground stimulates formation inside an oil palm fruit of free fatty acids (f.f.a.), through activation of enzymes present in the fruit. These enzymes break down chemical bonds joining fatty acids and glycerol—the two major components of vegetable oil glycerides. Once the molecular bonds are broken, fatty acids are freed within the oil. Their presence makes palm oil more expensive to refine, corrodes metals in processing and storage tanks, and creates unpleasant flavors and odors when oxidized. Formation of free fatty acids occurs most readily when fruits are very ripe.

Harvesters must therefore handle fruits as carefully as possible. Plantations are experimenting with harvesting cranes that catch fruit bunches in nets after they are cut loose, preventing fruits from striking the ground. Normal harvesting ensures high-quality oil if fruits move immediately to sterilization tanks, where exposure to heat terminates fruit lipase activity and discourages free fatty acid formation.

Oil with an f.f.a. content below 5 percent receives a premium on the market as an incentive to producers, because oil of this type causes refiners fewer effluent problems and gives resulting end products longer shelf life. As fruit bunches ripen, both oil content and f.f.a. content increase.

Good harvesting demands that workers select for removal those bunches with a balance of high oil content and minimum f.f.a. presence. Detached fruits are a sign that this ripening process is underway. Research findings indicate that a 10-20 percent ratio of detached fruit to total fruit usually marks the most desirable time to harvest.

Trees begin bearing marginally in the third year of growth. Immature fruit bunches are purple, developing a reddish-orange color as they ripen. An oil palm may yield 10 to 15 fresh fruit bunches per year, varying in weight from 10 to 50 pounds each. Oil palms yield continuously through the year. One tree may yield one bunch each month, while another yields three bunches in 1 week, followed by 2 months of no ripe fruit.

Overripe fruits must be removed; if left on or near palms, they attract pests and encourage disease as they decompose. Evidence supports the economic advantage of location and removal even of unhealthy inflorescences, a growth stage preceding formation of fruits. Rotted or poorly developed inflorescences can promote onset of fungi or pests, such as the *Pyralid* moth.

Squads of harvesters consequently operate in teams, generally working each assigned plot once every 2 weeks to insure regular contact with each tree. Bunches and loose fruits are carried to the roadside, then transported by truck or rail to the processing mill. Figure 1 diagrams subsequent treatment.

Bunches are first loaded in hoppers or cages and sterilized under steam for 50-75 minutes at a pressure of approximately 40 pounds per square inch. The steam not only deactivates the fruit lipase enzyme, but also helps loosen fruits from the bunch stalk. Thresher drums then knock the fruits loose from bracts, stems, and stalk, carrying the fruit away on channel bars. Stalk refuse is moved to incinerators as a fuel source for powering the mill. This incineration generates bunch ash, a suitable field mulch or supplementary fertilizer for maintaining potassium in soils.

Separated fruitlets proceed into a digester, are converted to mash, then pressed hydraulically or by a worm screw to release the crude oil. The byproducts of this operation—fiber from the palm fruit's mesocarp, and palm nuts (seed)—undergo further processing. The fiber, when dried, provides additional fuel material for mill operation. Nuts pass first into dehulling drums that crack the outside shell, then into hydrocyclones that spin kernels loose from the broken shells. Kernels are dried and transported to bins to await bagging. Shells are stored in bunkers as yet another mill fuel reserve.

Subsequent to pressing, crude oil must be dehydrated and cleaned of solid matter. Vacuum heaters allow palm oil to be dried at low temperatures without presence of air. This reduces the risk of oxidation, a reaction stimulated by heat and aeration of oil—the latter destroying natural antioxidants in crude oil. Processing techniques commonly in use minimize palm oil contamination by air, water, and

FLOW DIAGRAM FOR PROCESSING OF PALM OIL

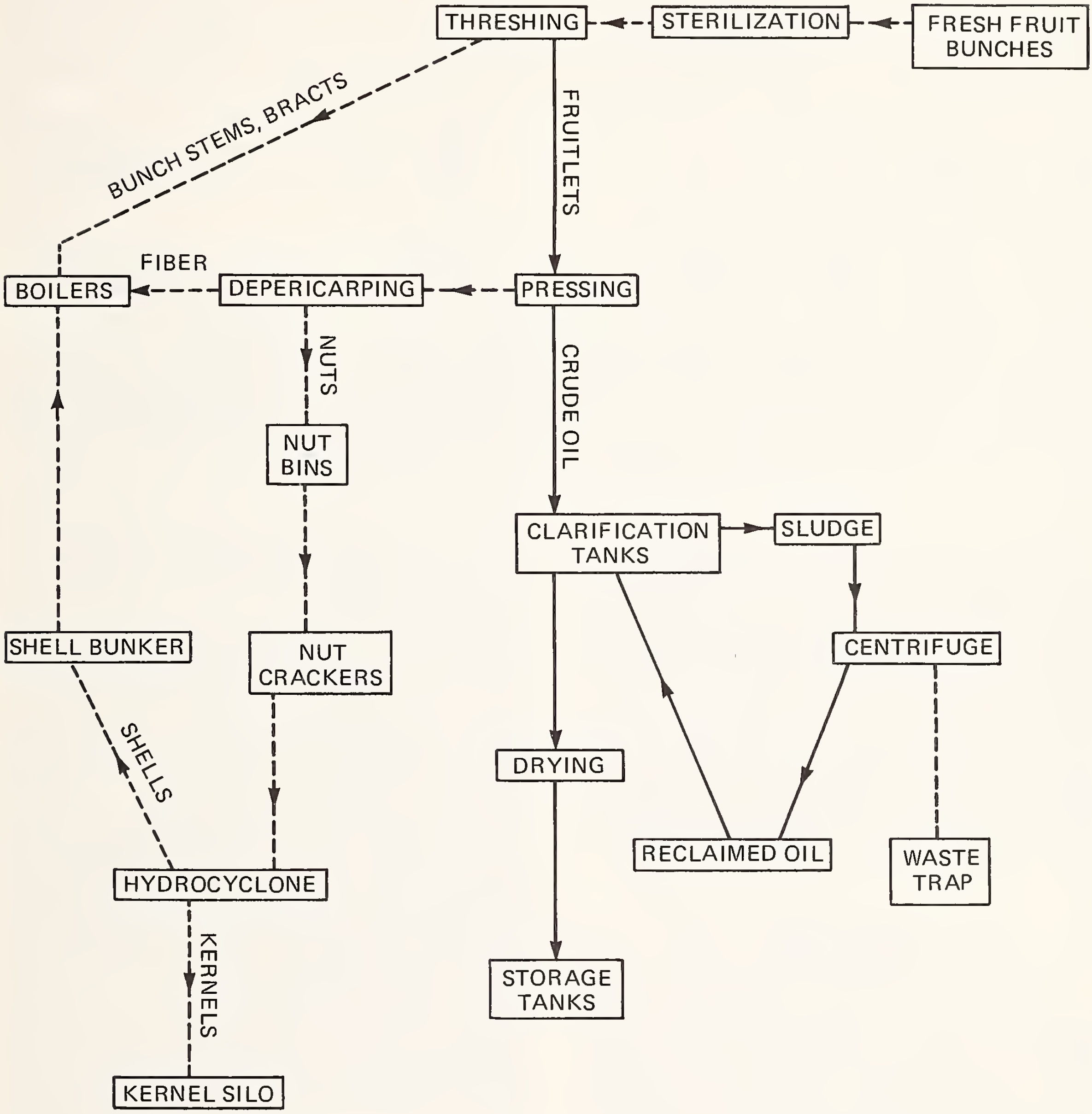


Figure 1.

metals, such as copper. Factories are equipped with quality control laboratories, which constantly inspect crude oil for presence of impurities.

Waste material from clarification tanks and discharge drains has created an effluent problem in peninsular waterways. Upon discharge, palm oil wastes often have a pleasant odor. When properly processed, palm oil solid wastes are suitable animal feeds that have compared favorably in feeding trials with conventional nutrients.

But untreated waste solids eventually decompose and reduce dissolved oxygen concentrations in waterways, upsetting biological balances and leaving unsightly sludge on riverbanks and in ditches. Methods under study for correcting the effluent problem generally incorporate a system using chemicals to coagulate the effluent, obtaining waste particle aggregates large enough to be separated by flotation or filtration.

Mills generally operate 16 hours per day, or around the clock during peak production periods. Mill capacities vary from 10 to 75 tons of fresh fruit bunches per hour, and average 35 tons of bunches per hour.

Assuming mills average 400 operating hours per month, the 90 palm oil mills presently in operation on the peninsula can deliver an approximate annual crushing capacity of 15.1 million tons of bunches or 3.0 million tons of oil equivalent—considerably above present West Malaysian palm oil production levels of 1.3 million tons.

Many mills are constructed to allow addition of further screw press units to accomodate larger volumes of fresh fruit bunch. West Malaysia's crushing capacity, therefore, should easily meet processing needs of its palm oil industry in the 1980's.

Refining

At present, 13 refineries in West Malaysia furnish the palm oil industry with a capacity to process 530,000 tons annually. But the Government has granted 45 licenses to construct and operate refining facilities, and from these expects to see at least 20 new refineries installed by 1980, each with an estimated 30,000-ton annual refining capacity. If accomplished, this expansion would boost Malaysian refining capacity to roughly 1.1 million tons by 1980, or nearly 50 percent of total production,

Refining of crude palm oil commonly includes four distinct processes:

Neutralization normally entails treating crude oil with an alkali, such as caustic soda, to effect a nearly complete removal of free fatty acids. These acids (and a small amount of neutral oil) are saponified—converted into soap—by this process.

Bleaching requires either heating the oil or treating it with bleaching earth to remove carotenoid pigments, which impart the red color characteristic of crude palm oil. The carotenoid pigment converts to vitamin A in man and other animals; hence, removal of this pigment to meet consumer preferences for clear cooking oil or white shortening also reduces nutritive value of palm oil.

Deodorization is accomplished by steam heating the relatively nonvolatile crude oil to remove relatively volatile taste and odor substances, while maintaining low pressures to prevent atmospheric oxidation of the oil.

Winterization. The major triglycerides, or fat molecules, in palm oil are oleodipalmitin—melting temperature of 35°C (96°F)—and palmitodiolein—melting temperature of 19°C (66°F). Therefore, at room temperature the latter group of triglycerides normally will melt while the former remains solid, separating the oil into liquid and solid fractions. Palm oil thus can also be fractionated through the winterization process. Chilled crude oil runs onto a conveyor belt, which suspends the solid portion (stearin) while allowing the liquid portion (olein) to separate and penetrate. Stearin serves as a pastry shortening and cocoa butter substitute, while olein is more suitable as a cooking and salad oil.

It presently costs Malaysians approximately US $28 per ton to neutralize palm oil. Yet during much of 1975 and early 1976 neutralized oil sold at a premium to crude oil of only US $11 per ton. Refiners at that time apparently were not covering costs, a misapprehension dispelled by closer examination of the Malaysian export tax policy.

Until the middle of 1976, refined oil left Malaysia duty-free (subject only to a small surcharge), while crude oil incurred an export tax and surcharge amounting to as much as US $247 per ton in February 1975. But by July 1976, the total export tax fell to only US $60 per ton, because the ad valorem tax reflected the fall in world palm oil prices and palm oil export value.

Refined oil sold at a small premium to crude oil. Yet the delivered price of both refined and crude oil covered this export tax, which exporters of refined oil did not have to pay. Producers saved the amount of the export tax on every ton of refined oil they sold. Even though the premium on refined oil was small, refiners easily covered costs.

But the Malaysian Government revised its policy of excusing refined oil from export taxes. Beginning in August 1976, exports of refined oil were subject to a variable duty determined by the degree of processing the oil had undergone. Neutralized oil was subject to a duty equal to approximately half of the duty on crude oil. Simultaneously, falling world prices of palm oil resulted in a lower export tax for crude oil.

Table 2.–WEST MALAYSIA: ESTIMATED SELLING MARGIN FOR CRUDE AND REFINED PALM OIL

(In U.S. dollars per metric ton)

Item	Producer cost[1]	Refining cost	Export taxes duty + surcharge	Total	Price (f.o.b.)	Margin
Crude:						
February 1975	190	–	247	437	470	33
August 1976	195	–	[2]60	255	390	135
October 1976	195	–	75	270	398	128
Refined:[3]						
February 1975	[4]243	25	[5]13	297	481	184
August 1976	[4]350	28	34	412	401	–11
October 1976	[4]343	28	42	413	420	7

[1] Production cost for crude oil; acquisition cost of crude oil to refineries for refined oil. Production cost is a weighted average of estimated private plantation costs (17-18¢/kilo) and FELDA scheme costs (22¢/kilo). FELDA constitutes approximately one-third of West Malaysia's oil palm area. [2] Gazetted August 1976 taxes less than in February 1975 reflect lower world palm oil prices in mid-1976 relative to those of late 1974. [3] Neutralized. [4] F.o.b. price of crude oil less export taxes for crude oil plus $20 premium. [5] Refiners required to pay surcharge.

Sources: Export taxes are partially from FAS reports; the balance, along with prices and estimates of producer costs, are from trade sources.

Refiners were immediately affected. Payable export tax rates on refined oil rose. Refiners pay, for crude oil, the f.o.b. price of crude oil plus a premium less the actual gazetted export tax on crude oil. Consequently, as crude oil export taxes fell, the acquisition cost of crude oil for refiners rose.

Refiners were caught temporarily in a profit squeeze, and managed to attain minimal returns by raising the price premium slightly on refined oil. The industry's operating rate reportedly was reduced during the last quarter of 1976.

Despite initial difficulties, it is unlikely that the reformulated export tax policy will permanently discourage refiners from production. Trimmed selling margins make a return on investment even more dependent than before upon volume of production. And the new export tax policy encourages export of highly refined oil by attaching progressively smaller taxes to more completely processed palm oil products. As a result, there will likely be more rather than less refined palm oil exported from Malaysia in the next few years.

Bulking and Shipping Facilities

Palm oil enters bulking installations by truck or coastal tanker for export shipment. Tests determine moisture content of the oil as it enters storage tanks. Weight measurements on stamped receipts certify the amount of oil pumped into tanks at the point of delivery. Delivered oil is measured again after storage by marking the height of oil inside tanks before and after pumping, allowing for effects of temperature on oil volume.

In West Malaysia, palm oil storage tanks vary in capacity from 500 to 5,000 tons. Tanks holding 2,000 tons or more occasionally incur undesirably excessive fuel costs. Oil must be heated before being pumped from storage tanks to ships. When delivery calls for loading 500 or 1,000 tons, tanks holding 2,000 tons or more must be entirely heated to the proper temperature before discharge, wasting fuel to heat oil that remains in the tank. Most bulking installations therefore maintain tanks of varying size to accommodate a wide range of delivery orders at minimum fuel costs.

West Malaysia can store approximately 300,000 tons of palm oil–including bulking capacity for crude oil of roughly 225,000 tons and additional storage space in refineries estimated at 75,000 tons.

Further bulking capacity will be provided at the coastal city of Kuantan, just below the southern tip of Trengganu, in Pahang. This port and storage center will traffic oil from Pahang and Trengganu–oil that now travels 200 miles or more by truck to bulking centers in the South or West. By 1980, Kuantan facilities will hold up to 75,000 tons of palm oil.

Total storage capacity is expected to reach 550,000 tons by 1980, including bulking capacity of approximately 360,000 tons for crude oil, 90,000 tons storage capacity at refineries, and 100,000 tons storage capacity at mills. Bulking centers are well distributed on the peninsula to minimize overland transportation of oil from mills. Port Butterworth in Penang and Port Klang near Kuala Lumpur, with a capacity of 150,000 tons, primarily service the states of Perak, Selangor, and Pahang. Most of Johore's oil moves to the installations in Singapore and, increasingly, to the newer center at Pasir Gudang on the Malaysian side of the Johore Straits. By 1980, these two centers will have combined storage space for palm oil amounting to 125,000 tons.

Ships carrying palm oil from West Malaysia generally call at Penang, Kuala Lumpur, and Singapore, proceeding via Kuantan to the Philippines for coconut oil. Deliveries in the United States generally begin on the West Coast (Portland) and continue to New Orleans and New York. Tankers move palm oil to four key ports in Europe (Liverpool, London, Rotterdam, and Hamburg), often loading chemicals for the return voyage. A round trip from Malaysia to European ports and back via the United States averages 60 days, while the route through the Suez Canal requires only 35 days.

Modern shipping companies are coating bare steel tanks aboard vessels with epoxy to prevent rust from contaminating the palm oil being transported. Tank temperature may be adjusted for different heat needs, such as ship passage through cold waters or discharge at destination.

Trade and Government Policy

Malaysian palm oil comprises 70 percent of world palm oil exports. The European Community (EC) traditionally has provided the largest market for palm oil (trimming its share in recent years from 70 percent to 40 percent) despite the 8-12 percent tariff rate the EC levies on palm oil imported for edible purposes. But in recent years the United States and a few Asian markets, taken together, have drawn a larger share of world palm oil exports. Exports to the United States, Japan, India, Iraq, and Pakistan, averaged a 26 percent share of Malaysian palm oil exports between 1967 and 1970. By 1975, these markets' share had almost doubled.

U.S. imports alone doubled between 1974 and 1975, largely as expanded purchases of refined oil. Refined Malaysian palm oil was available for only a small premium over crude during 1974 and 1975, because of the Malaysian export tax policy. (See section on refining, page 6.) Furthermore, refined palm oil was directed to U.S. ports rather than to other major markets, because import taxes on refined palm oil exceed those for crude in Canada and the EC.

In 1976, roughly one quarter of West Malaysia's crude palm oil production—about 385,000 tons—entered refineries. However, only 35,000 tons were consumed domestically as an edible oil; many Malaysians are accustomed to using coconut oil for cooking purposes. A few refineries can process crude palm oil into end products, such as shortening and soap. But Malaysia also obtains these items from Australia and New Zealand, much of it manufactured from Malaysian crude palm oil.

Malaysia will be seeking new markets for the palm oil projected to be produced in the next decade. Pakistan has evinced a new, strong demand for palm oil in the past 2 years. Malaysian marketing efforts may convince other oil-deficit nations, such as India and Bangladesh, to follow suit. Other determining factors will be deficit nations' purchasing power, palm oil prices relative to those for other oils, the extent of the U.S. Public Law 480 program, and the importing countries' trade policies. India, for instance, withdrew a 30 percent duty on palm and rapeseed oils and a 15 percent duty on soybean oil in August 1976, inviting a boost in imports of those oils in 1977.

Malaysia plans to pursue the U.S.S.R. and the People's Republic of China (PRC) for palm oil sales, as both countries already import small amounts. But poor receiving facilities, uncertainty concerning substitutability and consumer receptivity, and political

Table 3.—PALM OIL: IMPORTS INTO SPECIFIED COUNTRIES, ANNUAL 1967-75

(In 1,000 metric tons)

Country	1967	1968	1969	1970	1971	1972	1973	1974	1975
United States	29	47	72	64	98	196	177	187	436
United Kingdom	99	109	139	162	228	208	244	223	206
Germany, West	99	126	133	116	150	151	152	133	210
Netherlands	65	71	77	89	129	161	160	147	186
Pakistan	9	—	1	2	1	3	1	27	178
Iraq	52	54	58	66	78	82	105	125	120
Canada	10	9	16	12	13	31	20	16	119
Japan	22	28	42	40	41	55	100	115	108
Total	385	444	538	551	738	887	959	973	1,563
U.S. as percentage of total	7.5	10.5	13.3	11.6	13.2	22.0	18.4	19.2	27.8

Source: FAS reports.

Table 4.–CRUDE PALM OIL EXPORTS FROM PENINSULAR MALAYSIA TO THE UNITED STATES AND TOTAL, MONTHLY JANUARY 1972-DECEMBER 1975

(In 1,000 metric tons)

Month	1972			1973			1974			1975		
	U.S.	Total	U.S. as percentage of total	U.S.	Total	U.S. as percentage of total	U.S.	Total	U.S. as percentage of total	U.S.	Total	U.S. as percentage of total
January	9.4	54.8	17.3	6.4	46.5	13.8	3.5	54.5	6.3	18.1	53.9	28.9
February	5.5	49.3	11.1	10.4	42.7	24.3	2.4	55.0	4.4	19.1	54.9	31.6
March	5.2	39.2	13.2	6.0	67.7	8.9	5.8	53.2	10.9	14.8	72.8	17.7
April	6.5	47.3	13.7	10.4	69.7	14.9	5.5	68.8	8.0	20.9	72.5	23.2
May	9.2	49.2	18.8	9.4	62.8	15.0	4.9	52.8	9.2	21.5	51.8	45.6
June	8.7	38.5	22.7	7.1	42.8	16.6	6.5	64.5	10.1	12.7	57.7	22.0
Subtotal	44.5	278.3	17.7	49.7	332.2	14.3	28.6	348.8	10.1	107.1	363.6	28.5
July	12.0	47.3	25.3	5.1	50.3	10.1	12.9	59.8	21.6	29.1	70.8	41.0
August	1.0	40.0	2.5	–	61.5	0	21.5	82.3	26.2	39.4	100.2	39.4
September	14.1	66.8	21.2	17.9	64.1	27.9	6.9	66.0	10.5	22.7	73.4	30.9
October	3.1	58.6	5.4	9.1	78.8	11.6	2.7	66.3	4.1	23.7	83.6	28.3
November	10.5	57.2	18.3	4.2	63.2	6.6	17.9	80.7	22.2	9.7	64.5	15.0
December	.5	77.1	.6	4.1	74.7	5.4	16.9	108.9	15.5	20.3	75.0	27.1
Total	85.7	[1] 625.4	13.7	90.1	[2] 724.8	12.4	107.4	[3] 812.8	13.2	252.0	[4] 831.1	30.3

[1] Excludes 3,000 metric tons of refined and semirefined palm oil exports. [2] Excludes 16,000 metric tons of refined and semirefined palm oil exports. [3] Excludes 58,000 metric tons of refined and semirefined palm oil exports. [4] Excludes 204,000 metric tons of refined and semirefined palm oil exports.

Source: Oil Palm Monthly Statistics of Malaysia.

Table 5.—WEST MALAYSIA CRUDE PALM OIL EXPORTS, MONTHLY 1968-75

(In 1,000 metric tons)

Month	1968	1969	1970	1971	1972	1973	1974	1975
January	29.8	25.9	24.3	38.4	54.8	46.5	54.5	53.9
February	23.9	20.9	22.3	32.2	49.3	42.7	55.0	54.9
March	17.7	27.1	27.0	44.4	39.2	67.7	53.2	72.8
April	13.4	20.9	27.2	36.4	47.3	69.7	68.8	72.5
May	24.3	29.4	34.3	49.4	49.2	62.8	52.8	51.8
June	10.4	28.2	21.5	39.6	38.5	42.8	64.5	57.7
July	25.2	22.4	33.1	58.0	47.3	50.3	59.8	70.8
August	22.0	22.0	33.5	38.6	40.1	61.5	82.3	100.2
September	17.1	33.8	36.0	53.6	66.8	64.1	66.0	73.4
October	29.9	36.9	30.7	40.2	58.6	78.8	66.3	83.6
November	33.1	34.4	39.1	43.5	57.2	63.2	80.7	64.5
December	21.1	28.9	43.8	61.0	77.1	74.7	108.9	75.0
Total	267.8	330.7	372.3	535.2	[1]625.4	[2]724.8	[3]812.8	[4]831.1

[1] Excludes 3,000 metric tons of refined and semirefined palm oil exports. [2] Excludes 16,000 metric tons of refined and semirefined palm oil exports. [3] Excludes 58,000 metric tons of refined and semirefined palm oil exports. [4] Excludes 204,000 metric tons of refined and semirefined palm oil exports.

Source: Oil Palm Monthly Statistics of Malaysia.

considerations weaken their candidacies as prospective large palm oil markets.

But being producers of relatively high-priced vegetable oil, these two countries might be persuaded to step up exports of domestically produced oil (sunflowerseed oil in U.S.S.R., peanut oil in PRC) and replace the exported oil with cheaper palm oil for domestic consumption. Malaysian and Indian officials have explored the feasibility of such a program with regard to India's peanut oil. Additional market opportunities may appear among Mideast members of the Organization of Petroleum Exporting Countries (OPEC).

In addition to the new export tax policy on refined oil the Government of Malaysia intends to take two other policy steps designed to accelerate palm oil exports. One action would establish a commodity exchange for palm oil in Malaysia.

Such a market exchange in Kuala Lumpur would organize and vivify world trade in palm oil, but its sustained operation requires more than the blessing of the Malaysian Government. The exchange also would need: (1) professional floor traders; (2) the involvement of trade dealers, large commodity purchasers and sellers who tie together a vast network of consumers; (3) public speculation on palm oil futures; and (4) strong turnover for futures clearance.

Without a full range of bidders at most price levels to give the market depth and resilience, the exchange would lack vigor. And without active involvement of trade dealers, continuous bidding activity among speculators is not likely to occur.

The second Government action would initiate a registration and licensing authority to assert careful regulation of the palm oil industry with regard to product quality and production control. Such an authority may be established during 1977.

Determinants of Yield

Yields of palm oil per planted hectare in 1965 averaged 1.54 tons; by 1975 yields improved to 2.13 tons per hectare. But average yields per hectare for bearing trees also jumped during this period—from 1.94 tons in 1965 to 2.71 tons in 1975. Careful harvesting techniques, improved transport of fruit bunches, and wider use of fertilizer account for this record. Yield per planted hectare fell between 1965 and 1970 as the rate of new plantings lowered the ratio of harvestable area to total planted area, even though yield per bearing tree improved.

Cultivation and processing techniques only partially explain yield variations. Weather comprises another portion of the answer. Yet bountiful rainfall and high yield are not always correlatable with regard to palm oil production.

For instance, higher rainfall generally tends to increase yields by stimulating leaf production, encouraging pollination, and providing moisture for root feeding. But heavy rainfall accompanied by high incidence of cloud cover encourages development of male inflorescences in the oil palm during the

Table 6.–WEST MALAYSIA: PALM OIL, ESTIMATED SUPPLY AND DISTRIBUTION, ANNUAL 1969-75, ESTIMATED 1976, AND PROJECTION 1977 AND 1980

Supply and Distribution	Unit	1969	1970	1971	1972	1973	1974	1975	Estimated 1976	Projection 1977	Projection 1980
Supply:											
Stocks, January 1		25	14	36	44	66	51	98	169	171	200
Production	1,000 Metric tons	326	403	551	659	740	942	1,135	1,244	1,510	2,140
Imports	1,000 Metric tons	–	2	4	1	–	1	1	–	–	–
Total supply	1,000 Metric tons	351	419	591	704	806	994	1,234	1,413	1,681	2,340
Distribution:											
Exports	1,000 Metric tons	331	372	535	628	740	871	1,035	1,207	1,490	2,150
Crude		331	372	535	625	724	813	831	857	940	1,200
Refined		–	–	–	3	16	58	204	350	550	950
Apparent domestic disappearance		6	11	12	10	15	25	30	35	35	40
Stocks, December 31	1,000 Metric tons	14	36	44	66	51	98	169	171	156	150
Total distribution	1,000 Metric tons	351	419	591	704	806	994	1,234	1,413	1,681	2,340
Plantation area:											
Total planted	1,000 hectares	242	273	311	359	419	494	532	561	595	674
Estimated harvested[1]		162	201	242	273	311	359	419	494	573	634
Harvested as a proportion of total planted area	Percent	67	73	78	76	74	73	79	88	96	94
Yield per harvested area	Metric tons per hectare	2.01	2.00	2.28	2.41	2.38	2.62	2.71	2.53	2.77	3.49

[1] Mature palms 3 years of age and older.

Sources: Oil Palm Growers Council, Oil Palm Monthly Statistics of Malaysia, and FAS estimates and projections.

Malaysia's Palm Oil

Malaysia, the world's leading producer and exporter of palm oil, confidently expects to expand its present 70 percent share of world palm oil exports to 78 percent by 1980. Malaysia's palm oil refining and fractionation facilities are the most sophisticated in existence.

Right: Sample bottle of crude palm oil shows separation, at room temperature, of oil into liquid and solid fractions—olein has risen to the top, leaving solid stearin at bottom.

Top portion of pages, from left: A field of young oil palms in West Malaysia; Mature oil palm laden with fruit; A worker carries newly harvested fresh fruit bunches from an oil palm grove; At a processing mill, fruit in rail cage cars is sterilized under steam for 50-75 minutes prior to crushing.

Bottom portion of pages, from left: After fruit is crushed, crude oil is piped at high temperature to clarification tanks for filtration; Bulking installation at ports store palm oil in tanks that vary in capacity from 500 to 5,000 tons. Oil is warmed by thermopack units or live steam before being piped to tanker ships for export.

Table 7.–WEST MALAYSIA: OIL PALM PRODUCTIVITY PER HECTARE

Year	Production	Total area	Harvestable area[1]	Total area harvestable	Yield on	Planted area	Yield on	Harvestable area
	1,000 M.T.	*1,000 Ha.*	*1,000 Ha.*	*Percent*	*M.T./Ha.*	*Pounds/ Acre*	*M.T./Ha.*	*Pounds/ Acre*
1965	149	97	77	.79	1.54	1,374	1.94	1,731
1970	403	273	201	.73	1.48	1,317	2.00	1,784
1975	1,135	532	419	.79	2.13	1,903	2.71	2,418
1980[2]	2,225	674	634	.94	3.30	2,944	3.51	3,132
1985[3]	2,850	828	816	.99	3.44	3,069	3.49	3,114

[1] Trees 3 years of age and older. [2] Estimated. [3] Projected.

Sources: Oil Palm Growers Council, Oil Palm Monthly Statistics of Malaysia, and FAS projections.

primordial stage of development, 18 to 24 months before emergence of inflorescences.

Though these contribute pollen to the sexual reproduction cycle, male inflorescences do not develop into fruit bunches, which yield palm oil. Hence, a lower sex ratio (female to male) in the oil palm can result in decidedly lower yields. But high light intensity-characteristic of periods with no cloud cover and, therefore, little rainfall-causes a high female/male sex ratio among developing inflorescences, which can lead to higher oil yields.

Furthermore, low rainfall levels do not insure poor yields. Oil palms in podzolic loamy sands (laterite soils that have undergone podzolization) with water tables 30 centimeters below surface profit in extremely dry periods from simultaneous exposure to high moisture content in the subsoil and plentiful sunshine.

Growth and yield of oil palm fruits are nevertheless hampered by prolonged periods of low rainfall. Moisture stress apparently has an appreciable effect on yield: (1) Within 10-12 months after the stress period, resulting from abortion of female inflorescences (which form the oil-bearing fruits); and (2) within approximately 18-24 months after the stress period, by altering the sex ratio of inflorescences, causing abortion of floral initials during sex differentiation.

Later in the study, factors are enumerated accounting for failure of actual palm oil production in West Malaysia to reach potential production levels determined in table 9c. Figure 2 suggests that variation in rainfall helps promote such divergences. In table 8, annual rainfall totals (averaged for stations distributed throughout peninsular Malaysia) are expressed as a percentage of rainfall levels in a base year, 1973.

In figure 2, actual production as a percentage of potential production is graphed against time. Rainfall data are lagged 1 year. In two of three cases when rainfall levels decreased during the period treated, the actual/potential production ratio fall sharply. In the third case, the actual/potential ratio rate of increase slowed markedly.

The palm oil industry is approaching full production potential over time, indicating improvement in overall efficiency of processing and harvesting methods. But rainfall deficits reverse the upward trend in actual production efficiency vis-a-vis potential production levels.

Production Projections

Oil palms bear marginally in the third year of growth. Yields increase until the tenth year, peak, then gradually decline. Trees are commercially productive for 30-35 years. An age distribution of all oil palms in West Malaysia during a given year allows estimation of potential production of palm oil, once average yields of trees at each age are determined by growing trials or observation testing.

Table 9 presents an estimated age distribution of oil palms in West Malaysia, using historical area figures with corresponding yield estimates. Yield estimates in this table originate at the Malaysian Agricultural Research and Development Institute (MARDI). Estimates are for *Dura* x *Pisifera* progenies, *(Tenera)* with densities of planting, fertilizer application, rainfall, and management assumed constant.

As tree groups advance in age, each year they move into new yield classifications, because yields differ among age groups. Calculated production from all age groups of a given year, based on indicated area and yield, is totaled to show potential production for that year.

Actual palm oil production figures for West Malaysia are, in each calendar year, lower than potential production figures. Effects of rainfall deficits, processing difficulties, and inefficient harvesting techniques all hinder actual production from reaching full potential levels. However, a strong correlation exists between actual palm oil production levels (A)

Table 8.–WEST MALAYSIA: AVERAGE ANNUAL RAINFALL AT SELECTED STATIONS[1]

Year	Malacca	Kuantan	Mersing	Alor Star	Kota Bharu	Kuala Trengganu	Penang	Ipoh	Sitiawan	Overall average	Average rainfall (base year: 1973)
	Inches										Percent
1955	82.31	99.49	96.14	82.00	83.90	89.21	92.52	89.08	58.70	85.93	0.761
1956	82.91	114.59	116.12	91.10	139.25	94.40	95.06	104.30	61.79	99.95	.885
1957	88.68	126.39	101.66	85.37	101.84	112.81	94.07	94.09	66.09	96.78	.857
1958	94.23	87.12	87.67	68.19	98.05	88.73	101.35	86.61	57.68	85.51	.757
1959	80.28	106.38	110.45	94.37	131.38	125.50	78.53	98.11	89.34	101.59	.900
1960	79.27	117.83	126.44	88.62	115.38	98.53	82.05	98.00	70.33	97.38	.862
1961	65.96	123.32	120.13	82.42	123.67	119.63	87.71	83.56	72.78	97.69	.865
1962	73.71	121.65	114.38	78.54	97.22	84.12	102.75	92.88	57.28	91.39	.809
1963	56.77	74.93	83.62	71.45	71.29	87.70	81.58	91.49	66.53	76.15	.674
1964	79.53	130.13	120.85	70.94	80.66	82.02	113.14	87.78	76.64	93.52	.828
1965	82.01	113.53	84.49	96.67	133.97	125.69	95.67	96.24	69.39	99.74	.883
1966	87.16	134.88	116.89	91.24	118.84	147.73	96.17	107.69	76.00	108.51	.961
1967	79.90	168.05	144.71	89.17	142.22	113.28	83.10	86.75	72.10	108.80	.963
1968	79.73	94.32	88.29	67.17	127.33	117.87	95.80	84.34	65.58	91.16	.807
1969	87.68	91.18	102.52	91.77	105.65	103.19	103.71	92.71	62.95	93.48	.828
1970	81.94	124.15	110.90	93.90	88.98	106.57	128.08	107.46	72.11	101.57	.899
1971	72.23	164.79	135.91	97.66	109.32	78.72	98.44	78.80	61.40	99.70	.883
1972	55.32	110.98	96.56	90.49	74.33	77.32	90.03	94.41	63.58	83.67	.741
1973	83.30	123.97	135.75	88.70	146.47	124.24	113.17	120.91	79.90	112.93	1.000

[1] All data except percentages are expressed as inches per year.

Source: Malaysian Meteorological Service, Climatological Division.

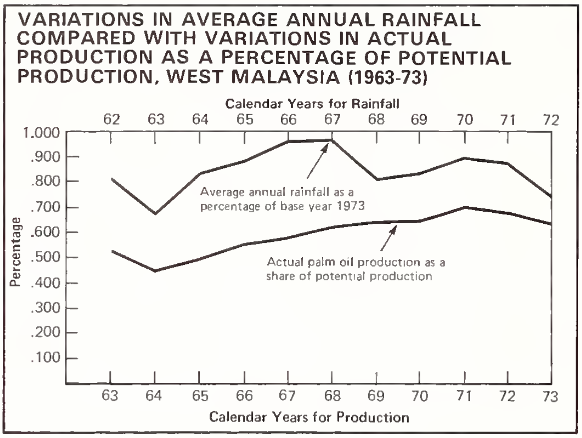


Figure 2

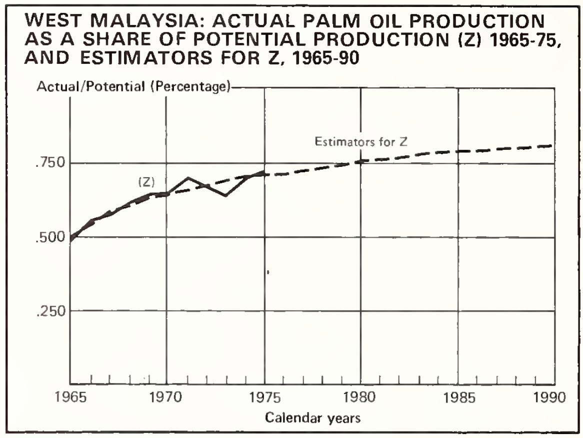


Figure 3

and potential palm oil production (P) in table 10. Using potential production as the independent variable:

$$A = .755\ P - 66.733$$
$$R^2 = .9945;\ S.E. = 16.2755$$

Actual production projections within this model require the assumption that actual production achieves the same share of potential production over time. However, expressing actual production as a percentage share of potential production (Z in table 11) shows that despite effects of the random factor rainfall, actual production gradually approaches full potential levels. Tighter control over pest and disease damage, wider use of fertilizer, and improvement in cultivation and harvesting practices account for this progress.

Regression analysis using natural logarithms of the actual/potential production ratio (Z) and time (T) indicates that an exponential function attains (figure 3) such that the ratio of actual production and estimated potential production increases at a decreasing rate:

$$\ln Z = -.705 + .153\ \ln T$$
$$R^2 = .9303;\ S.E. = .0243$$

This nonlinear function generates estimators for Z (table 11), from which actual production estimates are calculated ($\hat{A}$ in table 11 and "projection for A" in figure 4).

The function retains potential production as an explanatory variable, yet allows for an increase in the forecast actual production/potential production ratio—a trend discernible in the West Malaysian palm oil industry.

Estimates after 1980 in table 11 indicate a range for palm oil production to allow for the uncertainty inherent in projecting new plantings after 1980. (Production figures do not diverge until 1983, because of lags in productivity of immature trees.) Planting intentions during the period 1976-80 (table 9) are already determined in the Third Malaysian Plan, covering the same period. But plantings subsequent to 1980 may be increased or cut back relative to previous years, depending upon current or projected prices of palm and other edible oils in 1980 and world demand for palm oil.

Recent Malaysian Government indications suggest that oil palm plantings during 1981-90 will be sharply below those of the previous period, averaging 20,000-30,000 hectares total during the 5-year periods 1981-85 and 1986-90 represented by the low end of the area projection range in table 9. Reasons for this possible cutback may be related to: (1) Malaysian Government regulations restricting acquisition of new arable land by private plantations; (2) uncertainty over the market for palm oil in the 1980's; and (3) hesitancy of Malaysian Government policy makers to encounter problems with palm oil similar to those endemic to the rubber industry, whose prices in the 1950's plummetted with resulting sharp declines in export earnings the economy had come to depend upon heavily.

Palm oil production projections in table 11 and figure 4 therefore include a "low estimate" for potential production (P_L in figure 4) and for actual production (A_L) using the new planting estimates for 1981-90 indicated above. The low estimate assumes commercial production of palms ages 1-30. Table 11 and figure 4 also project potential and actual palm oil production in West Malaysia for a "high estimate" (P_H and A_H) calculated utilizing more optimistic new planting estimates for 1981-90.[1] The higher estimate assumes (1) new plantings at four to five times the annual rate of present estimates from Malaysian Government officials, and (2) commercial production of palms ages 1-35.

[1] Area estimates used in "Malaysian Palm Oil Export Market Development Strategy," W. D. Scott & Co., Pty. Ltd., October 1974.

Table 9.–WEST MALAYSIA: ESTIMATED OIL PALM AGE DISTRIBUTION AND PALM OIL PRODUCTION, 1965-90

(Area in 1,000 Hectares, Production in 1,000 metric tons, Yield in MT/Hectare)

Age of Tree	1 Year		2		3		4		5		1-5		6		7		8		9		10		6-10	
Average yield[2]	–		–		.20		1.61		2.97		.96		4.42		4.89		5.16		5.31		5.44		5.04	
Calendar year	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production	Area/Percent		Area	Production	Area	Production	Area	Production	Area	Production	Area	Production	Area/Percent	
1965	14	–	8	–	13	3	5	8	2	6	42	44	4	18	6	29	12	62	16	85	16	87	55	56
1966	26	–	14	–	8	2	13	21	5	15	66	54	2	9	4	20	6	31	12	64	16	87	41	33
1967	39	–	26	–	14	3	8	13	13	39	100	62	5	22	2	10	4	21	6	32	12	65	30	18
1968	38	–	39	–	26	5	14	22	8	23	126	63	13	57	5	24	2	10	4	21	6	33	30	15
1969	41	–	38	–	39	8	26	42	14	42	158	66	8	35	13	64	5	26	2	11	4	22	33	14
1970	32	–	41	–	38	8	39	63	26	77	176	64	14	62	8	39	13	67	5	27	2	11	42	16
1971	38	–	32	–	41	8	38	61	39	116	188	61	26	115	14	68	8	11	13	69	5	27	66	21
1972	48	–	38	–	32	6	41	66	38	113	197	55	39	172	26	127	14	72	8	42	13	71	100	28
1973	60	–	48	–	38	8	32	51	41	122	219	52	38	168	39	191	26	134	14	74	8	44	126	30
1974	74	–	60	–	48	10	38	61	32	95	252	51	41	181	38	186	39	201	26	138	14	76	158	32
1975	38	–	74	–	60	12	48	77	38	113	259	49	32	141	41	200	38	196	39	207	26	141	176	33
1976[4]	59	–	38	–	74	15	60	97	48	142	280	47	38	168	32	156	41	212	38	202	39	212	188	34
1977[4]	34	–	59	–	38	8	74	119	60	178	266	42	48	212	38	186	32	165	41	218	38	207	197	33
1978[4]	38	–	34	–	59	12	38	61	74	220	244	36	60	265	48	235	38	196	32	170	41	203	219	35
1979[4]	22	–	38	–	34	7	59	95	38	113	192	28	74	327	60	293	48	248	38	202	32	174	252	38
1980[4]	18	–	22	–	38	8	34	55	59	175	172	24	38	168	74	361	60	310	48	255	38	207	259	38
1981	6	–	18	–	22	4	38	61	34	101	119	17	59	261	38	186	74	382	60	319	48	261	280	39
1981	24	–	18	–	22	4	38	61	34	101	137	20	59	261	38	186	74	382	60	319	48	261	280	38
1982	6	–	6	–	18	4	22	35	38	113	91	13	34	150	59	289	38	196	74	393	60	326	266	37
1982	24	–	24	–	18	4	22	35	38	113	127	18	34	150	59	289	38	196	74	393	60	326	266	35
1983	6	–	6	–	6	1	18	29	22	65	59	09	38	170	34	166	59	304	38	202	74	403	244	34
1983	24	–	24	–	24	5	18	29	22	65	113	15	38	168	34	166	59	304	38	202	74	403	244	31
1984	6	–	6	–	6	1	6	10	18	53	42	06	22	97	38	186	34	175	59	313	38	207	192	26
1984	24	–	24	–	24	5	24	39	18	53	115	14	22	97	38	186	34	175	59	313	38	207	192	24
1985	6	–	6	–	6	1	6	10	6	18	30	04	18	80	22	108	38	196	34	101	59	321	172	23
1985	24	–	24	–	24	5	24	39	24	71	121	15	18	80	22	108	38	196	34	101	59	321	172	21
1986	4	–	6	–	6	1	6	10	6	18	28	04	6	27	18	88	22	114	38	202	34	185	119	17
1986[5]	24	–	24	–	24	5	20	32	24	71	121	15	24	106	18	88	22	114	38	202	34	185	137	17
1987	4	–	4	–	6	1	6	10	6	18	26	04	6	27	6	29	18	93	22	117	38	207	91	13
1987[5]	24	–	24	–	24	5	24	39	24	71	121	14	24	106	24	117	18	93	22	117	38	207	109	13
1988	4	–	4	–	4	1	6	10	6	18	24	04	6	27	6	29	6	31	18	96	22	120	59	09
1988[5]	24	–	24	–	24	5	24	39	24	71	121	14	24	106	24	117	24	124	18	96	22	120	77	09
1989	4	–	4	–	4	1	4	6	6	18	22	03	6	27	6	29	6	31	6	32	18	98	42	06
1989[5]	24	–	24	–	24	5	24	39	24	71	121	14	24	106	24	117	24	124	24	127	18	98	61	07
1990	4	–	4	–	4	1	4	6	4	12	20	03	6	27	6	29	6	31	6	32	6	33	30	05
1990[5]	24	–	24	–	24	5	24	39	24	71	121	13	24	106	24	117	24	124	24	127	24	131	49	05

Table 9.–WEST MALAYSIA: ESTIMATED OIL PALM AGE DISTRIBUTION AND PALM OIL PRODUCTION, 1965-90

(Area in 1,000 Hectares, Production in 1,000 metric tons, Yield in MT/Hectare) - (Continued)

Age of Tree	11		12		13		14		15		11-15		16		17		18		19		20		16-20	
Average yield[2]	5.26		5.16		5.04		4.89		4.79		5.04		4.67		4.55		4.45		4.35		4.25		4.45	
Calendar year	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production	Area/Percent		Area	Production	Area	Production	Area	Production	Area	Production	Area	Production	Area/Percent	
1965	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1966	16	84	–	–	–	–			–	–	16	13	–	–	–	–		–	–	–	–	–	–	–
1967	16	84	16	83	–	–	–	–	–	–	32	20			–	–	–	–	–	–	–	–	–	–
1968	12	63	16	83	16	81	–	–	–	–	45	22	–	–	–	–	–	–	–	–	–	–	–	–
1969	6	32	12	62	16	81	16	78	–	–	51	21	–	–	–	–	–	–	–	–	–	–		
1970	4	21	6	31	12	60	16	78	16	77	55	20	–	–	–	–	–	–	–	–	–	–	–	–
1971	2	11	4	21	6	30	12	59	16	77	41	13	16	75	–	–	–	–	–	–	–	–	16	05
1972	5	26	2	10	4	20	6	29	12	57	30	08	16	75	16	73	–	–	–	–	–	–	32	09
1973	13	68	5	26	2	10	4	20	6	29	30	07	12	56	16	73	16	71	–	–	–	–	45	11
1974	8	42	13	67	5	25	2	10	4	19	33	07	6	28	12	55	16	71	16	70	–	–	51	10
1975	14	74	8	41	13	66	5	24	2	10	42	08	4	19	6	27	12	53	16	70	16	68	55	10
1976[4]	26	137	14	72	8	40	13	64	5	24	66	12	2	9	4	18	6	27	12	52	16	68	41	07
1977[4]	39	205	26	134	14	71	8	39	13	62	100	17	5	23	2	9	4	18	6	26	12	52	30	05
1978[4]	38	200	39	201	26	131	14	68	8	38	126	20	13	61	5	23	2	9	4	17	6	26	30	05
1979[4]	41	216	38	196	39	197	26	127	14	67	158	24	8	37	13	59	5	22	2	9	4	17	33	05
1980[4]	32	168	41	212	38	191	39	191	26	124	176	26	14	65	8	36	13	58	5	22	2	9	42	06
1981	38	200	32	165	41	207	38	186	39	187	188	28	26	121	14	63	8	36	13	57	5	21	66	10
1981	38	200	32	165	41	207	38	186	39	187	188	27	26	121	14	63	8	36	13	57	5	21	66	09
1982	48	252	38	196	32	161	41	200	38	182	197	29	39	182	26	118	14	62	8	35	13	55	100	15
1982	48	252	38	196	32	161	41	200	38	182	197	27	39	182	26	118	14	62	8	35	13	55	100	14
1983	60	316	48	248	38	191	32	156	41	196	219	32	38	177	39	177	26	116	14	61	8	34	126	18
1983	60	316	48	248	38	191	32	156	41	196	219	29	38	177	39	177	26	116	14	61	8	34	126	17
1984	74	389	60	310	48	242	38	186	32	153	252	36	41	191	38	173	39	174	26	113	14	60	158	23
1984	74	389	60	310	48	242	38	186	32	153	252	33	41	191	38	173	39	174	26	113	14	60	158	21
1985	38	200	74	382	60	302	48	235	38	182	259	37	32	149	41	187	38	171	39	170	26	111	176	25
1985	38	200	74	382	60	302	48	235	38	182	259	33	32	149	41	187	38	171	39	170	26	111	176	22
1986	59	310	38	196	74	373	60	293	48	230	280	39	38	177	32	146	41	182	38	167	39	166	188	27
1986[5]	59	310	38	196	74	373	60	293	48	230	280	33	38	177	32	146	41	182	38	167	39	166	188	23
1987	34	179	59	304	38	191	74	361	60	287	266	38	48	224	38	173	32	140	41	178	38	162	197	29
1987[5]	34	179	59	304	38	191	74	361	60	287	266	30	48	224	38	173	32	140	41	178	38	162	197	23
1988	38	200	34	175	59	297	38	186	74	354	244	35	60	280	48	218	38	169	32	137	41	174	219	32
1988[5]	38	200	34	175	59	297	38	186	74	354	244	27	60	280	48	218	38	169	32	137	41	174	219	25
1989	22	116	38	196	34	171	59	289	38	182	192	27	74	346	60	273	48	212	38	165	32	136	252	38
1989[5]	22	116	38	196	34	171	59	289	38	182	192	21	74	346	60	273	48	212	38	165	32	136	252	28
1990	18	95	22	114	38	191	34	166	59	283	172	25	38	177	74	337	60	268	48	208	38	162	259	39
1990[5]	18	95	22	114	38	191	34	166	59	283	172	18	38	177	74	337	60	268	48	208	38	162	259	28

Table 9.–WEST MALAYSIA: ESTIMATED OIL PALM AGE DISTRIBUTION AND PALM OIL PRODUCTION, 1965-90

(Area in 1,000 Hectares, Production in 1,000 metric tons, Yield in MT/Hectare)–(Continued)

Age of Tree	21		22		23		24		25		21-25		26		27		28		29		30		26-30[1]	
Average Yield[2]	4.15		4.03		3.90		3.81		3.76		3.93		3.71		3.63		3.53		3.48		3.36		3.53	
Calendar year	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production	Area/Percent		Area	Production	Area	Production	Area	Production	Area	Production	Area	Production	Area/Percent	
1965	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1966	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1967	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1968	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1969	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1970	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1971	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1972	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1973	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1974	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1975	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1976[4]	16	66	–	–	–	–	–	–	–	–	16	03	–	–	–	–	–	–	–	–	–	–	–	–
1977[4]	16	66	16	64	–	–	–	–	–	–	32	05	–	–	–	–	–	–	–	–	–	–	–	–
1978[4]	12	50	16	64	16	62	–	–	–	–	45	07	–	–	–	–	–	–	–	–	–	–	–	–
1979[4]	6	25	12	48	16	62	16	61	–	–	51	08	–	–	–	–	–	–	–	–	–	–	–	–
1980[4]	4	17	6	24	12	47	16	61	–	–	55	08	–	–	–	–	–	–	–	–	–	–	–	–
1981	2	8	4	16	6	23	12	46	16	60	41	06	16	59	–	–	–	–	–	–	–	–	16	02
1981	2	8	4	16	6	23	12	46	16	60	41	06	16	59	–	–	–	–	–	–	–	–	16	02
1982	5	21	2	8	4	16	6	23	12	45	30	04	16	59	16	58	–	–	–	–	–	–	32	05
1982	5	21	2	8	4	16	6	23	12	45	30	04	16	59	16	58	–	–	–	–	–	–	32	04
1983	13	54	5	20	2	8	4	15	6	23	30	04	12	45	16	58	16	56	–	–	–	–	45	06
1983	13	54	5	20	2	8	4	15	6	23	30	04	12	45	16	58	16	56	–	–	–	–	45	06
1984	8	33	13	52	5	20	2	8	4	15	33	05	6	22	12	44	16	56	16	56	–	–	51	07
1984	8	33	13	52	5	20	2	8	4	15	33	04	6	22	12	44	16	56	16	56	–	–	51	07
1985	14	58	8	32	13	51	5	19	2	8	42	06	4	15	6	22	12	42	16	56	16	54	55	08
1985	14	58	8	32	13	51	5	19	2	8	42	05	4	15	6	22	12	43	16	56	16	54	55	07
1986	26	108	14	56	8	31	13	50	5	19	66	-10	2	7	4	15	6	21	12	42	16	54	41	06
1986[5]	26	108	14	56	8	31	13	50	5	19	66	08	2	7	4	15	6	21	12	42	16	54	41	05
1987	39	162	26	105	14	55	8	30	13	49	100	15	5	19	2	8	4	14	6	21	12	40	30	04
1987[5]	39	162	26	105	14	55	8	30	13	49	100	12	5	19	2	8	4	14	6	21	12	40	30	03
1988	38	158	39	157	26	101	14	53	8	30	126	19	13	48	5	18	2	7	4	14	6	20	30	05
1988[5]	38	158	39	157	26	101	14	53	8	30	126	14	13	48	5	18	2	7	4	14	6	20	30	03
1989	41	170	38	153	39	152	26	99	14	53	158	24	8	30	13	47	5	18	2	7	4	13	33	05
1989[5]	41	170	38	153	39	152	26	99	14	53	158	18	8	30	13	47	5	18	2	7	4	13	33	04
1990	32	133	41	165	38	148	39	149	26	98	176	26	14	52	8	29	13	46	5	17	2	7	42	06
1990[5]	32	133	41	165	38	148	39	149	26	98	176	19	14	52	8	29	13	46	5	17	2	7	42	05

[1] Assumed commercial life of 30 years for low range. High range calculations for trees ages 31-35 affect only area and production after 1985. [2] Malaysian Agricultural Research and Development Institute Estimates. [3] Oil palm planting intentions between 1976-80 indicated in Third Malaysian Plan. [4] Includes trees aged 31-35, which do not appear on Table 9.

Sources: Area and age distribution data supplied in part by Ministry of Agriculture, Forestry, and Fishing of Malaysia, and the Oil Palm Growers Council. Yield data are from the Malaysian Agricultural Research and Development Institute.

Table 10.–WEST MALAYSIA: ESTIMATED OIL PALM AGE DISTRIBUTION AND PALM OIL PRODUCTION 1965-76, WITH PROJECTIONS, 1977-90[1]

Year[2]	Planted area (hectares)[3]	Potential production[3, 4]	Actual production	Average annual potential yield per planted hectare[3]	Average annual actual yield per planted hectare[3]
1965	97	303	149	3.11	1.53
1966	123	337	186	2.71	1.51
1967	162	376	217	2.32	1.33
1968	200	431	265	2.15	1.31
1969	241	508	326	2.10	1.36
1970	273	627	403	2.30	1.48
1971	311	785	551	2.52	1.78
1972	358	970	659	2.69	1.83
1973	419	1,152	740	2.74	1.75
1974	492	1,341	942	2.72	1.90
1975	531	1,549	1,135	2.92	2.13
1976[5]	590	1,786	–	3.02	–
1977[5]	624	2,069	–	3.32	–
1978[5]	662	2,341	–	3.54	–
1979[5]	685	2,614	–	3.82	–
1980[5]	703	2,834	–	4.03	–
1981	709	3,043	–	4.29	–
1981	727	3,043	–	4.19	–
1982	715	3,185	–	4.45	–
1982	752	3,185	–	4.24	–
1983	721	3,302	–	4.58	–
1983	776	3,306	–	4.26	–
1984	727	3,260	–	4.48	–
1984	800	3,293	–	4.12	–
1985	733	3,371	–	4.60	–
1985[6]	824	3,458	–	4.20	–
1986	721	3,299	–	4.58	–
1986[6]	849	3,519	–	4.14	–
1987	709	3,216	–	4.54	–
1987[6]	873	3,580	–	4.10	–
1988	701	3,138	–	4.48	–
1988[6]	897	3,649	–	4.07	–
1989	699	3,080	–	4.41	–
1989[6]	921	3,695	–	4.01	–
1990	699	3,028	–	4.33	–
1990[6]	945	3,751	–	3.97	–

[1] Assumed commercial life of 30 years for low range. [2] High range calculations for trees aged 31-35 affect only area and production after 1985. [3] After 1980; low range-assumed commercial life of 30 years for oil palm; new plantings for 1981-90 estimated by FELDA. High range-assumed commercial life of 35 years for oil palm; new plantings for 1981-90 estimated by trade sources. [4] Calculated from indicated area and yields. Divergence of actual production due to variations in weather, cultivation practices, and processing techniques. [5] Oil palm planting intentions between 1976-80 indicated in Third Malaysian Plan. [6] Included trees aged 31-35.

Sources: Area and age distribution data supplied in part by Ministry of Agriculture, Forestry, and Fishing of Malaysia, and Oil Palm Growers Council. Yield data from Malaysia Agricultural Research and Development Institute.

Estimates for actual production follow closely the trend in potential production. If area additions remain at a high rate through 1990, potential and actual production projections will continue to climb.

But if area additions during 1981-90 conform to present Malaysian Government estimates, potential and actual production are likely to follow the projected low range, which peaks in 1985 and gradually declines (figure 4). Table 10 explains this projected decline–anticipated by data for 1978, when the rate of growth for production in the low range begins falling.

Assuming the low rate of planting after 1980, table 9 shows that the last largest grouping of new oil palm plantings (planted between 1972-74) will have attained or passed, in 1978, the sixth year of age–the age at which the rate of increase in oil palm yields peaks. This initiates a gradual but steady decline in the annual rate of growth for both estimated potential production and projected actual production in the low range.

WEST MALAYSIA: PALM OIL POTENTIAL (P) AND ACTUAL (A) PRODUCTION, 1965-90

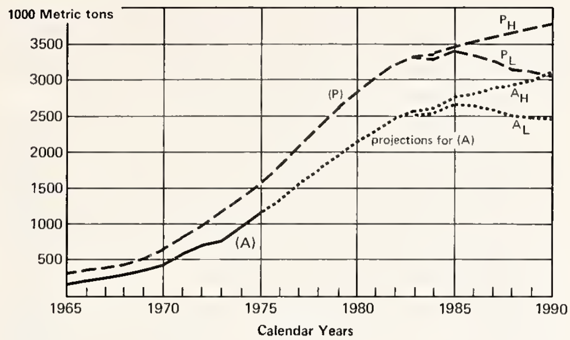


Figure 4

Oil Palm Breeding

Clonal breeding techniques offer the clearest opportunity for long-term improvement in production and yield of *Elaeis guineensis* in West Malaysia. Cross-pollination breeding techniques have, until recently, contributed most to improvement of oil palm yields through genetic experimentation. The *Dura* variety of oil palm possesses in its genetic structure an allele homozygous for thick kernel shell. Cross-pollination with the *Pisifera* variety, homozygous for absence of shell, generates the *Tenera* variety, whose fruit carry a thin shell and relatively large mesocarp (the oil-bearing portion of an oil palm fruit). *Pisifera* plantings are commercially useful only for breeding, being frequently female-sterile and subject to bunch failure.

There is evidence that improved oil palms result from crossing *Elaeis guineensis* with *Elaeis oleifera* (another species of oil palm, also called *Coroza oleifera* and *Elaeis melanococca).* A species with primarily South American distribution, *oleifera* palms produce fruits with thick shells and low oil yield, limiting commercial viability.

But the shorter trunk and more unsaturated oil of *oleifera* varieties (relative to *guineensis)* widen the range of favorable genetic possibilities open to oil palm breeders. Research trials in Colombia con-

Table 11.–WEST MALAYSIA: REGRESSION ANALYSIS OF PALM OIL PRODUCTION

Year	Potential production (P)[1]		Actual production (A)	Actual production as a proportion of potential production (Z)	Estimators for actual production as a proportion of potential production ($\hat{Z}$)[2]	Estimators for actual production projections ($\hat{A}$)[1]	
	1,000 Metric tons		*1,000 Metric tons*	*Percent*	*Percent*	*1,000 Metric tons*	
1965 . . .	303		149	.492	.494	150	
1966 . . .	337		186	.552	.549	185	
1967 . . .	376		217	.577	.584	220	
1968 . . .	431		265	.615	.611	263	
1969 . . .	508		326	.642	.632	321	
1970 . . .	627		403	.643	.650	408	
1971 . . .	785		551	.702	.665	522	
1972 . . .	970		659	.679	.679	659	
1973 . . .	1,152		740	.642	.691	796	
1974 . . .	1,341		942	.702	.702	941	
1975 . . .	1,549		1,135	.733	.712	1,103	
1976 . . .	1,786				.722	1,289	
1977 . . .	2,069				.731	1,512	
1978 . . .	2,341				.739	1,730	
1979 . . .	2,614				.747	1,953	
1980 . . .	2,834				.755	2,140	
1981 . . .	3,043	3,043			.762	2,319	2,319
1982 . . .	3,185	3,185			.769	2,449	2,449
1983 . . .	3,302	3,306			.775	2,559	2,562
1984 . . .	3,260	3,293			.781	2,546	2,572
1985 . . .	3,371	3,458			.786	2,650	2,718
1986 . . .	3,299	3,519			.792	2,613	2,787
1987 . . .	3,216	3,580			.798	2,566	2,857
1988 . . .	3,138	3,649			.801	2,514	2,923
1989 . . .	3,080	3,695			.808	2,489	2,986
1990 . . .	3,028	3,751			.813	2,462	3,050

[1] Low and high ranges are projected for calendar years 1981-90 except for (Z) where indicated ratio is applicable for entire range. ' [2] $\ln Z = .705 + .153 \ln T$ ($R^2 = .9303$; S.E. = .024).

Source: Actual production figures are in part supplied by the Oil Palm Monthly Statistics of Malaysia. Potential production figures are calculated from data in Table 9.

firmed, for example, that *oleifera* x *guineensis* hybrids resisted a spear-rot disease plaguing *guineensis* palms. Compared to *guineensis* plantings, this hybrid also developed over a shorter maturation period, reached bearing age at a smaller height, which facilitated harvesting and generated palm oil containing a preponderance of unsaturated triglycerides (62-65 percent) relative to oil from *guineensis* plantings (44-45 percent).

Commercial exploitation of *oleifera* varieties might reduce the need for assisted pollination by their tendency to develop parthenocarpic fruit, produced asexually in the plant. However, the disease resistance *oleifera* plantings have demonstrated in South America may wane on Malaysian soils. Plantation managers in Malaysia are therefore interested in, but cautious about, replanting damaged or aged *guineensis* with *oleifera* hybrids.

Scientists are now perfecting a vegetative breeding method for oil palms that could lift yields as much as 30 percent over present levels. Cross pollination transmits pollen from one parent tree to female flowers of another. In contrast, vegetative breeding involves selecting tissue samples from a single parent tree, nurturing them under controlled laboratory conditions, and planting them. When mature, these clones—or progeny—are close replicas of the parent tree, possessing identical genetic structure.

Oil palm hybrids are highly heterozygous, the characteristics of their progeny being, therefore, quite difficult to control. But vegetative breeding allows development of homozygous planting material exhibiting more uniform responses to soil maintenance and treatment.

Particular fruit bunch qualities will require less time to select and promote in progeny using vegetative breeding methods. Scientists utilizing traditional breeding techniques normally must let several generations pass to cultivate one tree with all desired characteristics. Vegetative breeding passes all traits immediately to the first generation. Those trees can be selected for breeding that have sturdiest disease and drought resistance, highest oil yield, preferred oil composition, most suitable height potential, and soil adaptability.

And, because seedlings have been successfully developed from leaf cells, root and trunk tissues, seeds, inflorescences, and pollen grains, a nearly unlimited supply of tissue samples can be procured from a single parent tree.

The significance of oil palm breeding innovations notwithstanding, conventional breeding techniques will continue to be relied upon to preserve for oil palm geneticists a wide range of genetic material, thus preventing any single pest or disease from wiping out an entire oil palm population of uniform variety.

Other Export Crop Options

A wide assortment of tropical crops grows well in peninsular Malaysia, but only a few could be produced on a scale extensive enough to supplement foreign exchange earnings of palm oil.

Tea: Major tea producers are located in the Cameron Highlands of northwest Pahang. Present area in West Malaysia stands at approximately 3,000 hectares. Large-scale development of tea plantations in peninsular Malaysia is hampered by limited highland area suitable for production.

Sugar cane: For climatic reasons, this crop grows primarily in the northeast sections of peninsular Malaysia. Sugarcane production centers in relatively cooler Perlis; moving southward, yields drop off significantly. Dearth of suitable land also discourages large-volume production of sugarcane.

Coffee: World market prices for coffee oscillate widely, precluding Malaysian dependence upon coffee export earnings as a major supplement for palm oil. This crop at present is grown primarily in Sabah and Sarawak, though West Malaysia maintains 8,000 hectares of coffee. The area now set aside to coffee can be expected to expand somewhat in the next decade as an earnings supplement to minor export crops such as tea, pepper, and coconut.

Coconut: Along coastal alluvial soils, these trees flourish and intercrop well with cocoa. But major expansion into coconut would place Malaysia in direct competition with the Philippines, which accounts for 50 percent of world production and 75 percent of world exports of copra and coconut oil. From 1960 until the present, coconut area in West Malaysia has remained within the range of 210,000-220,000 hectares. Coconut area should enjoy modest growth, stimulated by intercropping with cocoa, to a projected 1980 level of 235,000 hectares.

Rice: Rice area in West Malaysia nearly doubled from a 1960 total of 319,000 hectares to an estimated 611,000 hectares in 1976. Malaysia is 80 percent self-sufficient in rice production, making up the balance primarily through imports from Thailand.

However, Malaysia is at an absolute cost disadvantage to Thailand regarding rice production in major growing areas. And the Thai Government uses an export tax—the so-called rice premium—to maintain a wedge between world prices and domestic prices of rice, as a benefit to consumers. When world market prices drift upward and widen this wedge, smuggled rice moves across the border into Malaysia in large amounts—discouraging expansion of rice production in Malaysia.

Finally, the Malaysian Government has already established a high support price to stimulate rice production and thus meet domestic requirements.

Table 12.–WEST MALAYSIA: AREA OF SELECTED CROPS, 1960-76 AND PROJECTION FOR 1980 AND 1985

(In 1,000 hectares)

Year	Oil palm[1]	Rubber[1]	Cocoa[2]	Coconut[1]	Rice	Tea[2]	Coffee[2]
1960	55	1,574	1	210	319	5	4
1961	57	1,607	1	206	325	4	4
1962	62	1,679	1	206	395	4	4
1963	75	1,720	1	206	401	4	4
1964	83	1,742	1	206	401	4	4
1965	97	1,774	1	205	421	4	4
1966	123	1,774	2	205	426	4	4
1967	162	1,760	2	204	440	4	4
1968	201	1,734	2	209	479	3	4
1969	242	1,730	2	211	502	3	5
1970	273	1,724	2	213	533	3	6
1971	311	1,718	6	212	552	3	6
1972	359	1,702	11	211	572	3	7
1973	419	1,694	15	215	592	3	7
1974	493	1,692	19	217	597	3	8
1975[3]	532	1,675	22	217	603	3	8
1976[4]	590	1,659	24	219	611	3	8
1980[5]	703	1,599	61	235	[6] 710	3	12
1985[5]	733	1,539	81	243	[6] 806	3	16

[1] Estates and smallholders. [2] Estimate based on annual official total for cocoa, tea and coffee. [3] Indicated. [4] Estimated. [5] Projected. [6] $Y=308.4+19.7X$ $R^2=.9743$, S.E.=15.2.

Source: Ministry of Agriculture, Forestry, and Fishing, Malaysia.

The Malaysian Government will not likely invest significantly in rice as a major export crop during the 1976-80 period, though area for home consumption should expand to about 710,000 hectares in 1980 over the 1976 level of 611,000 hectares.

Cocoa: Not widely cultivated on the peninsula, Malaysian cocoa has traditionally been grown, like coffee, in East Malaysia. Cocoa trees in West Malaysia apparently succumb more easily to *dieback* disease than those in Sabah, partly because of deficiencies of proper fungi in peninsular soil. Yet West Malaysia's cocoa area grew from 2,000 hectares in 1970 to an estimated 24,000 hectares in 1976.

Recently, plantation owners have experimented with intercropping of coconut and cocoa. Early attempts to promote both crops on coastal sands met with mixed results; a number of cocoa trees suffered salt damage. Moving inland offered the advantage of less salty soils for cocoa growing. However, lack of cloud cover strained some cocoa trees, which are less hardy than oil palm or coconut plants. Intercropping with coconut served a useful purpose because the coconut trees supplied beneficial shade for cocoa plants without competing too keenly for nutrients.

Coconut has a distinct advantage over oil palm and rubber as an intercrop with cocoa. Oil palms are voracious feeders and supply too much shade for the sensitive cocoa trees. Neither cocoa nor coconut thrive well with rubber, which spreads the disease *phytophthera* to both plants. More recently, trials have shown that cocoa trees can flourish inland without traditional cover crops such as coconut or the leguminous *glearasidia,* provided proper fertilizer and irrigation are supplied. FELDA has established a 1,600-hectare cocoa scheme in central Pahang, near the middle of the peninsula. One private plantation in West Malaysia projects that by 1980 its area will be distributed as 40 percent rubber, 40 percent oil palm, and 20 percent cocoa. The plantation presently divides all of its area evenly between oil palm and rubber.

Cocoa prices—presently at record levels—bring more gross income per hectare for cocoa plantations in Malaysia than rubber or oil palm. As an export crop, cocoa now enjoys a healthy if somewhat erratic market. During 1976-80 cocoa profitability will generate either (1) modest replacement of aged and damaged oil palms or rubber trees with cocoa trees; or (2) new planting of undeveloped areas with cocoa rather than oil palm or rubber.

Rubber: Malaysia has committed itself to growth of the palm oil industry—at some expense to rubber expansion—spurred in part by the general trend toward use of synthetic rubber that began after World War II.

Continued high petroleum prices, forcing higher synthetic rubber prices, could produce a reverse substitution effect in favor of natural rubber. In

1976, Malaysia's volume of (natural) rubber exports increased for the first time in several years.

If, in addition, outlooks for consumption of natural rubber during the next two decades—now generally quite positive—continue to be favorable in 1978, FELDA and major private plantations in Malaysia will take a serious look at boosting rubber plantings once again, perhaps within the Fourth Malaysian Plan (1981-85).

Production Costs for Oil Palm and Rubber

For purposes of comparison regarding major crop profitability, production costs are estimated for palm oil and rubber. Table 12 contains three cost categories: Fixed, including administrative and overhead; variable, or direct; and transportation to port. In instances where costs for Government schemes and private estates differed, comparative analysis favored utilization of the former; nearly all oil palm area expansion in West Malaysia during the foreseeable future will occur in the form of Federal (FELDA) or State schemes.

Fixed: Settlement costs (in U.S. dollars per hectare) for oil palm schemes include: Felling and clearing, \$340; planting, \$1,473; housing and roads, \$756; and allocations for land input, \$824. Land allocation for FELDA schemes was computed considering the area as owned land valued at current prices for agricultural purposes. Rubber schemes require comparatively smaller mill establishment expenses. In addition, generally better land is set aside for oil palm planting. Consequently, a relatively lower allocation for land input and mill expenses generates the smaller fixed cost for rubber.

The Malaysian Government, through FELDA, owns the land used for scheme development. To compare potential profitability of rubber and oil palm stands requires consideration of cost for present or future production from new area. And nearly all new area during 1976-80 will be managed by FELDA on Government-owned land. Hence, allocation for land input is calculated as owned land at current prices for agricultural purposes.

Administration costs are averaged at US\$504 per hectare, and mill costs at US\$260 per hectare, derived from the 15 FELDA mills valued at US\$25 million, processing oil from 95,265 harvested hectares of oil palm on FELDA estates.

Variable: General maintenance charges for oil palm include replanting allowances, repairs, and irrigation. Fertilizer costs are based on an annual application per tree of 11 pounds ammonium sulphate and 4 pounds assorted mixture of magnesium, urea, or muriate of potash. The estimates for treatment of diseases and pests and assisted pollination are based on a sampling of harvester payments to FELDA for contracting services at average rates of respectively, 70 U.S. cents per ton f.f.b. and US\$1.75 per ton f.f.b. Processing costs in FELDA mills average US \$7.80 per ton f.f.b.

The rising costs of fertilizer, machine equipment, and fuel have been mitigated somewhat by improved oil palm yields and economies in palm oil processing.

Direct costs for rubber include tapping panels, weeding and draining (cultivation), fertilizer, disease and pest treatment, collection of latex, and processing. Harvesting techniques and yield constitute the major differences between variable costs of rubber and oil palm. Oil palm fruit bunches are hacked from the trunk, allowed to fall, and loose fruits are collected. But each rubber tree must be worked twice—once to tap the tree's panel and allow the latex to flow, and again to collect the latex that has gathered in a receptacle.

Furthermore, direct costs for rubber are distributed over an average total weight of harvested material per hectare that is much lower (1,009 kg per hectare) than that of the oil palm (2,962 kg per hectare on present FELDA estates).

This oil palm yield includes an average per hectare yield of palm oil (2,466 kgs) and palm kernel (493 kgs) in present FELDA schemes over the life of an oil palm tree, and allows for significantly lower yields during the first 5 years of growth.

Transportation: An average allowance is made for plantation-to-port expenses, which differ widely depending upon location of plantation and processing mills with respect to major ports.

Internal transportation costs vary both with the distance between a given scheme and the nearest crushing mill and the distance between a mill and the closest port. One estate in Selangor moves its fruit bunches only a few miles along a modern four-lane highway to the nearest mill, from where the extracted oil moves a short 30 kilometers to Port Klang. The closest port to some mills in central Pahang is 160-240 kilometers away over winding roads.

Total estimated production costs for palm oil of 22 U.S. cents per kilogram, f.o.b., are for FELDA schemes. Costs for established private estates are generally lower. Many older private estates have fully paid land and establishment expenses. Relative to smallholder schemes, practically all private estates enjoy superior productivity per harvester, quality of land, cultivation practices, processing techniques, and proximity of distribution centers. Production costs for a private estate in coastal Selangor or Perak would approximate 17-18 U.S. cents per kilogram.

Table 13.—WEST MALAYSIA: ESTIMATED PRODUCTION COSTS FOR RUBBER AND PALM OIL

(In U.S. cents per kg)

Type of Cost	Rubber Amount	Type of Cost	Palm Oil Amount
Fixed:		Fixed:[4]	
Total amortized[1]	4.4	Settlement cost[5]	4.4
		Administration	.7
		Mills	.4
	4.4		5.5
Variable:		Variable:	
Tapping	10.7	Maintenance	3.1
Cultivation[2]	3.8	Fertilizer[6]	3.3
Diseases and pests	.2	Diseases and pests	.4
Collection	15.0	Assisted pollination	1.1
Processing	2.6	Processing	4.9
	32.3		12.8
Transportation:		Transportation:	
Plantation to port	3.7	Plantation to port	3.7
	3.7		3.7
Total	[3] 40.4	Total	[3] 22.0

[1] Based on establishment costs of US $1,450 per hectare and an economic life of 30 years for rubber trees. [2] Includes weeding, draining, and fertilizer. [3] f.o.b., excluding export taxes. [4] Based on establishment costs of US $1,680 per hectare and an economic life of 30 years for oil palm trees. [5] Includes felling and clearing costs, construction, roads, and allocation for land input. [6] Computed from average fertilizer costs on FELDA schemes of US $10 per hectare per month.

Sources: Figures are averages based on surveys of private and Government plantations and mills in Malaysia.

Profitability Relationships and Implications for Diversification

Production costs tell only part of the story with respect to profitability of rubber and oil palm schemes. Each product faces additional charges during export from Malaysia. Rubber incurs separate taxes for research and development, replanting charges, export, and support of an exchange and licensing board—all amounting to roughly 5-6 U.S. cents per kilogram, dry weight. Palm oil faces both an export duty and a surcharge whose total has varied from US $247 per ton in February 1975 to US $59 per ton in July 1976. These taxes have an impact on profits, whether on the plantation, the mill, or refinery.

Yield variation further complicates determination of profit per hectare of an oil palm or rubber scheme. Area for both crops is distributed between private estates and smallholder schemes or plots. With rubber, the ratio of private to smallholder is roughly 35:65; for oil palm, 60:40. Yields per hectare in the private sector are slightly higher because the production and management activity is somewhat more meticulous on older, established estates. These distinctions may disappear as workers on newer schemes gain experience and as the trees they harvest mature.

Shipping charges for rubber are assumed to average slightly higher than those for palm oil. Practically all palm oil leaves Malaysia at rates controlled by shipping agreements between the Malaysian Palm Oil Producers' Association and major shipping lines. Conference rates are not as comprehensive with regard to rubber transportation.

World rubber prices varied from an average 1975 level of 66 U.S. cents per kilogram to an average January-June 1976 level of 87 U.S. cents per kilogram. These prices convert into an estimated range for average gross revenue per hectare of US$142-$356, assuming a yield of 1,009 kilograms of rubber per hectare, dry weight. World prices of palm oil and palm kernels during the same periods varied from 62 and 40 U.S. cents per kilogram, and 20 and 24 U.S. cents per kilogram, respectively. With yields of 2,466 kilograms per hectare for palm oil (assuming a normal distribution of immature trees) and 493 kilograms per hectare for kernels, a hectare of oil palms would gross an estimated US$242-$619.

Table 14.–OIL PALM AND RUBBER: ESTIMATED RANGES FOR GROSS REVENUE[1]

(In U.S. cents per kg)

Item	Rubber		Oil Palm					
	Case I	Case II	Palm oil I	Palm kernel I	Total I	Palm oil II	Palm kernel II	Total II
World price	65.9	87.1	61.5	20.3	81.8	39.7	24.3	64.0
Production cost, f.o.b.	41.9	41.9	22.0	[2] 7.5	29.5	22.0	[2] 7.5	29.5
Cost, insurance, freight	4.4	4.4	3.3	2.2	5.5	3.3	2.2	5.5
Export taxes	5.5	5.5	13.2	–	13.2	7.5	–	7.5
Gross revenue per kilogram	14.1	35.3	23.0	10.6	33.6	6.9	14.6	21.5
Gross revenue per hectare[3]	142.3	356.2	567.2	52.3	619.4	170.2	72.0	242.1

[1] Case I computes gross revenue estimates using average world prices for calendar 1975; Case II uses average world prices for January-June 1976. Prices for rubber, No. 1 grade smoked sheets, basis New York; palm oil, tank wagons, basis New York; palm kernels, c.i.f., Europe. [2] Production costs for palm kernels primarily accounted for within palm oil production costs, kernels being a derivative product from palm oil processing. Indicated figure covers separating kernel, drying, bagging, and transporting. [3] Assumed yields per hectare for computation; rubber, 1,009 Kgs; palm oil, 2,466 Kgs; palm kernel, 493 Kgs. Revenue per hectare expressed in U.S. dollars; all other figures in chart expressed as U.S. cents per kilo.

Sources: Rubber prices supplied by Malaysian Rubber Bureau. Palm oil and kernel prices from *The Public Ledger.* Production costs originate in Table 12.

Accurate cost and revenue data for cocoa plantations in West Malaysia are not readily available, as the few cocoa plantations in existence on the peninsula were only recently established. But cocoa clearly has money-making potential for Malaysia. One plantation owner estimated revenue, discounting fixed costs, at US$1.28 per kilogram. Assuming a yield of 675 kilograms per hectare–conservative even for West Malaysia's young cocoa schemes–a cocoa plantation on the peninsula would net US$864 per hectare, not including fixed costs.[2] It must be noted that these plantations incur high fixed costs, particularly those located in the interior of the peninsula, where extensive irrigation and intercropping of cover trees such as *glearasidia* or coconut are desirable. Coconut trees, if intercropped, would contribute to revenue on a cocoa plantation.

Yet sizable investment requirements and market uncertainty will not hold back cocoa plantings, if cocoa remains the profitable crop it presently appears to be. Its success may spur further plantings on the peninsula.

Presently the Malaysian Government limits the amount of land private plantations can purchase for agricultural expansion.[3] So, whether FELDA incorporates cocoa into its 1976-85 expansion plans remains a key factor in growth of cocoa area during the next few years.

The Malaysian estate owner and smallholder face several constraints when deciding whether or not to diversify or replant and, if so, to what crop:

- The long waiting period for maturing of new trees–3 years for oil palm, 4 years for cocoa, 6 years for coconut, and 7 years for rubber.
- The limited number of ready markets for export crops in which Malaysia has a comparative advantage.
- Government limitations on land acquisition by private estates, who will therefore be forced to substitute trees rather than expand. Some rubber trees are old enough to replace, but few oil palms are.
- The memory of unfavorable rubber prices in the 1960's, which has prodded the Government and private estates into crop diversification.

Production costs can be deceptive signals for those attempting to predict at what world price producers of palm oil or rubber will stop producing one product

[2] Assuming world prices of US$2.40 per kilogram. The indicated revenue figure takes into account a loss factor. FELDA's cocoa scheme, for example, sustained a 20 percent yield loss in 1975 because of disease.

[3] The Government motivation for setting this regulation is a political one. Smallholders on FELDA schemes eventually own the land they tend. Prime peninsular soil protected by law for later occupation by FELDA smallholders becomes land saved for the people.

and switch to another. Oil palm and rubber plantations are not likely to halt production in the event of low prices. Oil palms in particular require constant harvesting for sanitary reasons. If fruit bunches are left on the trees, they rot–attracting pests and spreading disease to adjacent stands. Too, as long as producers can cover variable costs, they are loathe to let trees, which represent real capital, stand unproductive.

When to tear out old trees and replant–if the decision to replant is made–depends upon the relationship of annual net revenue from an existing tree and the amortized present value of net revenue from a new tree. When these are equal–their equality depending upon yield, crop price, and establishment costs–the optimum age to replant is reached in that year. At present, the optimum replanting age for oil palm is approximately 30 years, and practically all commercially grown oil palms in West Malaysia will still be under 30 years of age by 1980.

As a result, replanting of existing oil palm stands with new oil palms or an alternative crop probably will not occur before 1980, except for the very small number of stands needing replacement after damage by storms, pests, or disease.

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