The Optimal Age of Oil Palm Replanting

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ABSTRACT

Malaysia is expected to only contribute 45.6% of the world palm oil output in 2005, a decrease of 4.5% compared to production in the year 2001. The declining contribution to world palm oil output is in part attributed to the lower production due to the increase in the aged oil palm trees. It is important that old palms, which are less economic to maintain be replanted, hence ensuring a continuous productive Malaysian oil palm industry. The question arises as to what age is oil palm economically suitable for replanting?

The objective of this paper is to determine the optimum age for oil palm replanting. Following Faris (1960) the optimum age of replanting is when the marginal net revenue in year n of the present stand is equal to or exceeds the amortised value of net revenue in year n of the second stand. It is concluded from this analysis that the optimum replanting age depends on the price of fresh fruits bunches (FFB), cost to establish and maintain new palms, technology that changes the yield profile, and the discount rates adopted. In Malaysia, it is found that the optimal replanting age lies between 25 and 26 years if the FFB price is RM 200 per tonne. The replacement age declines to between 24 - 25 years if the FFB price rises to RM 220 per tonne.

INTRODUCTION

In the year 2001, a total of 3.5 million hectares of land was planted with oil palm in Malaysia, of which 59.4% was owned by the private sector, 30.8% by government agencies and 9.8% by independent smallholders (*Table 1*). Government agencies that manage oil palm estates are FELDA, FELCRA, RISDA and state government land schemes. Out of the total planted area, three million hectares were mature and 493 745 thousand hectares were immature.

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TABLE 1. DISTRIBUTION OF OIL PALM PLANTED AREA BY OWNERSHIP CATEGORY 2001

Ownership category	Total planted area (ha)	Percent
Private estates	2 079 342	59.43
Govt. schemes:		
FELDA	612 742	17.51
FELCRA	165 528	4.73
RISDA	48 605	1.39
State schemes	249 454	7.13
Independent smallholders	343 342	9.81
Total	**3 499 012**	**100.00**

Source: Malaysian Palm Oil Board (2001).

TABLE 2. MATURE AND IMMATURE OIL PALM AREA, MALAYSIA 2000-2001

Age class	Area (ha)	
	2000	2001
Mature	2 941 791	3 005 267
Immature	434 873	493 745
Total	**3 376 664**	**3 499 012**

Source: Malaysian Palm Oil Board (2001).

Generally, oil palm reaches its peak yield of FFB between the sixth to the twelfth year after planting. Thereafter, the yield gradually decreases. Given a constant price, the decline in yield erodes some of the profit margin. In Malaysia, a large part of the land planted with oil palm, especially in private estates, has reached an average age of 20 years indicating that there is a need for palm replacement. Programmes for oil palm replanting should be undertaken through a systematic replanting plan, and should incorporate the usage of high quality seeds and improved technology and management system.

A major management decision facing oil palm owners is when to replace existing stands of the oil palm. This problem is compounded by the nature of the palm oil production cycle, which can generally be divided into three phases: (a) a period of non-productive phase lasting three years after planting, (b) a period of steadily rising yield reaching a peak level between the ages of six to 12 years, and (c) a period of declining yield. The last phase of the cycle is invariably associated with rising costs of production and falling profit, and it is then that the oil palm is considered for replanting.

CONCEPTUAL FRAMEWORK

The tree-replanting model is a modified form of the general replacement model, which has been discussed extensively in the economic literature. There are two basic replacement decision models used in the study of the replanting of trees: deterministic and stochastic. The deterministic model assumes that the probability of an event's occurrence is equal to one, and hence the expectations of all variables are single-valued. The stochastic model on the other hand, has a transition matrix, which specifies the probabilities of the occurrence of events from one state to another among the variables through each time period. For tree replanting, the most crucial productive variable is yield expectations.

Faris (1960) discussed the decision criterion for determining the optimal replacement of three types of production assets, which had different production periods and revenue-generation characteristics. These assets were (a) dry-lot cattle feeding operation which had a short production period, of approximately six months, with revenue being realized when the assets were sold, (b) timber which had a long production period of approximately 50 years, with revenue being realised when the assets were sold, and (c) peach trees which had an intermediate productive life, approximately 25 years, with revenue being realized throughout the life of the assets.

The criterion for replacement in all three cases was found to be when the marginal net revenue generated from the present enterprise become equal to the highest amortised present value of the anticipated net revenue generated from the enterprises mentioned. In general, the criterion for replacement was when the marginal net revenue of the productive asset was equal to or exceeds the amortised present value of the expected net revenue from replacing the productive assets.

Ward and Faris (1968) who studied the problems of replanting date palm trees in California employing the stochastic approach took explicit account of the probabilities of the yield variances through time. The results using the stochastic approach were compared with the results using the deterministic approach, which required less data and simpler computation technique. The replacement implications of the two approaches were found to be essentially the same and the stochastic approach did not necessarily provide the decision maker with better quantitative basis for evaluation. Because of this, it was decided that the deterministic approach be adopted in the current study due to its simpler computation technique.

A study was also done by Ani (1971) regarding the determina tion of optimum ages for oil palm replanting in Malaysia. He used the method outlined by Faris (1960) with revenue determination being done by combining the yields of oil palm and kernel. The price used was not that of FFB but those of crude palm oil (CPO) and kernel. Ani found from his study that the optimal age for oil palm replanting was more than 31 years old. However at this age, the trees would be too tall and less feasible to be harvested.

METHODOLOGY

The method adopted to determine the optimum replanting age in this study is in terms of maximizing net revenue over time. This is done by comparing the marginal net revenue from the existing stand with the estimated amortised present value of net revenue from the following stand. Following Faris (1960), the optimum replanting age is determined when the marginal net revenue (MNR) in year n of the present stand is equal to or exceeds the amortised present value of net revenue (AVNR) in year n of the second stand. The relevant equations are set out in *Appendix 1*.

Illustrative Examples to Determine the Optimal Age of Oil Palm

Figure 1 shows the graph depicting the determination of the optimum age on the principle explained earlier. The blue graph represents MNR and while the red graph represents AVNR The optimal time for replacement is when the MNR is equal to AVNR. From *Figure 1*, there are two points where the MNR is equal to AVNR. These are points A and B. After point A, the MNR from the present stand is higher than the AVNR from the following stand of oil palm trees. This indicates that the present stand is giving greater returns than the following stand. After point B however, the MNR from the present stand is lower than the AVNR from the following stand. After this point, profit obtained from the following stand of trees is greater than that of the present stand. Hence point B would be the time that is optimal for the oil palm trees to be replanted.

DATA AND ASSUMPTIONS

It is generally assumed in this analysis that oil palm planting and harvesting will continue in to the future. In fact, many current palm oil producers may be uncertain over future prices and costs. With their pessimistic outlook, they tend to defer replanting. It is hoped that this analysis will assist producers in their decisions whether to replant and when.

Production

It is assumed in this study that oil palms can be maintained and harvested up to the age of 32 years. After that, harvesting is not feasible because of the height problem.

Two yield profiles are considered in this study. The first is for the current stand and the second is for the following stand. The estimated yield profiles for the two stands of D x P seedlings over 25 years are based on data from the Biology Unit of MPOB, with the yield profiles for the extra seven years being extrapolated from the existing data. The two yield profiles are shown in *Appendix 2*.

Cost

The costs involved in this analysis are those for the current stand and the following stand. For the following stand, the real cost is assumed to have increased by 5%[1] from the current stand.

The estimated costs for the immature area (one to three years), which include land clearing lining, holing, seedling planting, fertilizer and other data items are collected from estates in 2000 (Malaysian Palm Oil Board, 2001). These costs are shown in *Table 2.*

Land costs are not included in this analysis, on the assumption that they remain constant in both the current and future periods. The estimated costs for the mature area are based on expenses incurred by the sampled estates.

The costs of harvesting were collected from the same sample. The figures collected are summarized in *Table 3*. It is found that the cost of harvesting a tonne of FFB increases with the age of the oil palms.

Wage Increase Consideration

A major cost component in the oil palm estate is the labour input. This important farm input had in the past suffered a serious supply problem, due to the rural-urban migration phenomenon. This makes local estate labour in short supply due to the keen competition from other sectors especially those located in the urban areas. Owing to supply pressure, wage rates were bid upwards. This has to be accounted for in our analysis in order to reflect the real world in which the oil palm estates operate.

In the cost computation, material and labour costs have been

[1] Base on annual growth rate for wage rate from year 1980 to 200

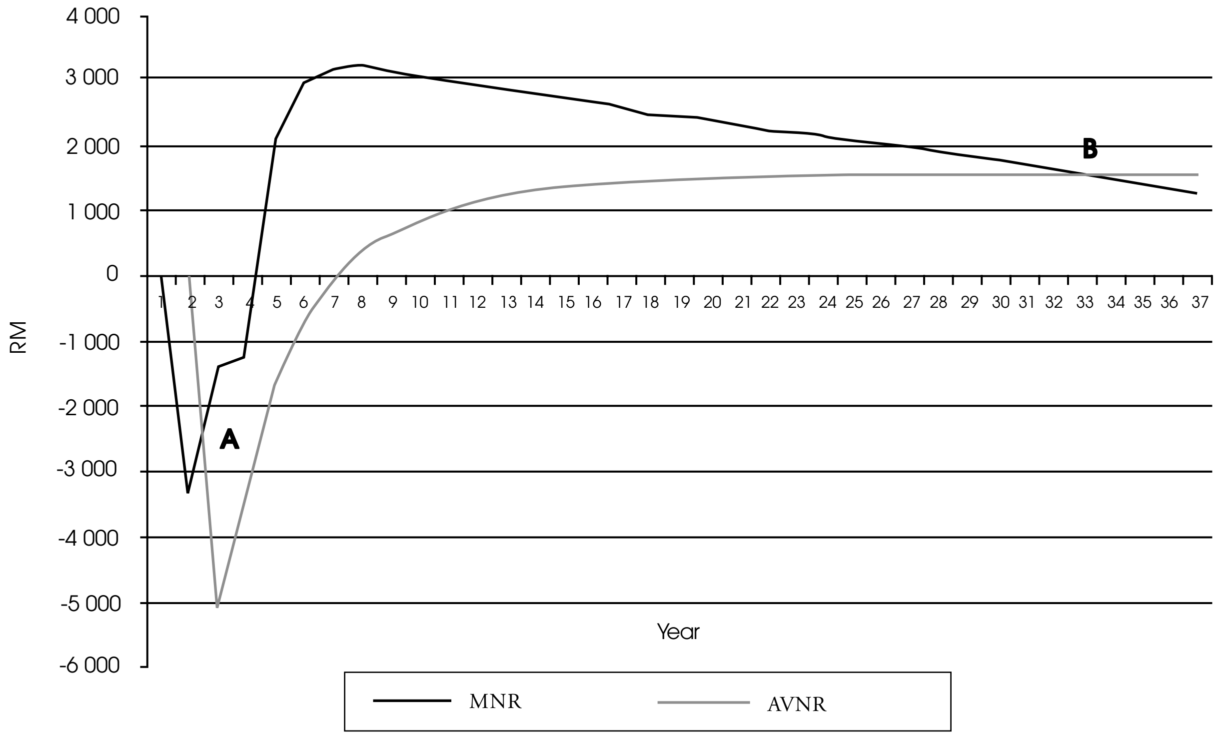

Figure 1. Determination of optimal replacement age of oil palm.

lumped up together. To incorporate the real increase in labour would be problematic. The solution is that we assumed an across-the-board increase in cost of the following oil palm stand by 5%, which ranges from RM 1700 to RM 3500 in annual cost as mention earlier. This adjustment is judged to edequately account for the increase in the wage rate on oil palm estates.

Output Prices

The FFB prices used in this analysis, was based on CPO prices. The prices taken are also to be assumed constant over the budg eting period, since the investment decision in this involves a long planning horizon and real rather than nominal values are consi dered. In order to determine the optimal age of oil palm replanting, three FFB price levels for the current and expected period are used, namely RM 180, RM 200 and RM 220 per tonne. These three price levels are selected in light of the FFB average price for the last 20 years of RM 195 per tonne (*Appendix 3*).

RESULTS AND DISCUSSION

The discussion regarding the optimal replanting age for oil palm concentrates on two scenarios. The first scenario assumes that the current and expected prices are similar. In the second scenario, the current and expected FFB prices are assumed to be different.

As mentioned earlier, three price levels and one discount rate are used in analysing both situations.

Current and Expected Prices at the Same Level

It is found that the optimal replanting age is earlier when the expected price of FFB is higher. At an average FFB price level of RM 180 per tonne, and a discount rate of 10%, the optimal replanting age is 27 years (*Table 4*). When the average price of FFB rises to RM 200 per tonne, the optimal replacement age of the palms shortens to 26 years. If the average price level of FFB is RM 220 per tonne, the palms should be replanted after the 25th year.

Expected Price Below the Current Price

If the expected price in this second scenario is below the current price, it leads to a delay in replanting. At an expected average FFB price of RM200, a current average FFB price of RM 220, and a discount rate of 10%, the optimal replanting age is 29 years (*Table 5*). When the expected average price of FFB is RM 180 and the current average price of FFB is maintained at RM 200 per tonne, optimal replacement of the palms is in the 30th year.

Expected Price Above the Current Price

On the contrary, it is found that if the expected price is higher than the current price, the optimal

TABLE 2. AVERAGE COST OF IMMATURE AREA, PER HECTARE PER YEAR, 2000

Cost	Year		
	1	2	3
Non- recurrent Costs:	**2 023.09**	-	-
Felling and clearing	606.43	-	-
Terracing and platform	216.29	-	-
Road construction	201.26	-	-
Drain construction	84.09	-	-
Lining and holing	199.33	-	-
Planting material	555.41	-	-
Other Non-recurrent Costs	160.28	-	-
Upkeep and Cultivation:	**701.15**	**799.34**	**674.26**
Weeding	150.78	81.32	233.49
Lallang control	26.98	28.71	53.12
Drains	49.95	41.67	33.69
Roads, bridges, paths, *etc.*	85.06	63.75	73.52
Soil/water conservation	29.57	39.45	13.77
Boundaries and survey	29.20	10.85	5.8
Cover crops	156.16	57.42	56.22
Census and supply	26.94	47.14	23.04
Pruning	15.05	17.83	29.04
Pests and diseases	78.45	96.31	73.1
Castration	16.20	19.33	38.9
Other costs of upkeep	36.81	95.56	40.44
Fertilization:	**254.59**	**447.42**	**498.84**
Fertilizers	197.25	361.85	414.42
Fertilizer application	44.34	73.76	73.87
Soil and water analysis	13.00	11.81	10.58
Total	**2 978.83**	**1 246.76**	**1 173.13**

Source: Malaysian Palm Oil Board (2001).

TABLE 3. HARVESTING COST PER TONNE OF FFB

Year	Cost (RM)
3 - 4	21
5-15	23
16-25	25
26-28	26
29-30	27
> 30	30

Source: Palm Oil Research Institute of Malaysia and Palm Oil Registration and Licensing Authority (1999).

replanting age is much earlier. At the expected average FFB price of RM 200 and RM 220 at a current average FFB price of RM 180, the optimal replanting age is in the 17th year (*Table 6*).

These results indicate that changes in current and future prices affect the optimum replant ing age directly. At current and expected prices of the same level, the higher an average FFB price, the shorter the optimal replanting age. Increases in average price increases profitability such that investment costs are recovered in a shorter period of time.

TABLE 4. OPTIMAL REPLANTING AGE AT DIFFERENT PRICES (current and expected prices are equal)

FFB price per tonne	Discount rate (10%) Marginal net revenue (RM)	Amortised value of net revenue (RM)	Optimal age
Current and expected price: RM 180	608.00	565.15	27
Current and expected price: RM 200	1 591.82	1 530.46	26
Current and expected price: RM 220	1 932.75	1 928.36	25

TABLE 5. OPTIMAL REPLANTING AGE AT VARIOUS PRICES (expected price below the current price)

FFB price per tonne	Discount rate (10%) Marginal net revenue (RM)	Amortised value of net revenue (RM)	Optimal age
Current price: RM 220	1 698.60		29
Expected price: RM 200		1 565.10	
Current price: RM 200	1 199.50		30
Expected price: RM180		1 173.24	

TABLE 6. OPTIMAL REPLANTING AGE AT VARIOUS PRICES
(expected price above the current price)

FFB price per tonne	Discount rate (10%)		
	Marginal net revenue (RM)	Amortised value of net revenue (RM)	Optimal age
Current price: RM 180	1 359.55		17
Expected price: RM 200		1 285.32	
Current price: RM200	1 746.15		17
Expected price: RM 220		1 663.17	

Expectations of future price also influence the optimal replanting age. The higher the expected fu ture prices the shorter the optimal replanting age. This is because, the net revenue from the following stand becomes greater than that from the present stand. In other words, the potential earning from the following oil palm cohort is greater than if no replanting is undertaken.

Effect Short-Term Price Increase

As found in the above sections, long-term product price increases relative to costs shortens the planting cycle of oil palm. However, in late 1997 and the whole of 1998, the palm oil market firmed up leading to a dramatic price increase of CPO. In 1998, price had increased to a record high of RM 2500 per tonne CPO. Due to this increase, most palm oil producers withheld their plans to replant. This can be seen as behaviour opposite to the above finding. In fact, the reaction of the palm oil producers is con sistent and can be explained from the economics viewpoint.

In general, the price increase in the mentioned period was believed to the temporary. It provided an opportunity for producers to increase earnings, and advantage was taken by producing the most by withholding replanting and har vesting even over-mature palms (Clark ,1976). This continues until the market reverts back to the equilibrium point and prices decline. Then it is again rational for producers to re-execute the original plan for oil palm replanting.

CONCLUSION

By 2001, the total oil palm area in Malaysia had reached 3.5 million ha while in Indonesia the total area had expanded to nearly 3.1 million ha. The age profiles of oil palm in Indonesia are mostly very young indicating highly productive palms, while the profiles of palms in Malaysia are much older. Older palms in Malaysia especially those that are more than 30 years old need replanting due to economic rational. New planting utilizing the current D x P seedlings and em ploying the latest management techniques including those related to new agronomic practices ensure future productivity improvement. Similarly improved cloned seed lings such as PS1, PS2 and PS3 are already available through research conducted by MPOB, thereby strengthening the productivity improvement potential.

The planting of these new seedlings will make available to the world the new high value palm products and help strengthen the Malaysian palm oil industry. Malaysia may not continue to be the world's largest producer of palm oil, due to its limitation in land resource and its escalating labour cost, but the country can continue to provide the world with high quality competitively priced palm products. But old palms need to be replanted once the optimal replanting age has been reached. Reduced replanting in 1997 and 1998 was due to the producers taking advantage of the short-term high palm oil prices.

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APPENDIX 1

In this case, year n is an equal number of years after planting for both stands.

The net revenue in any one-year is expressed by

$$NR_n = Y_n - [(a_{n-1}\, i) + b_n + c_n]$$

where

Y_n = Gross revenue
$a_{n-1}\, i$ = Interest on unpaid balances for establishment and land cost
b_n = annual costs
c_n = field establishment costs
n = age in years

In order to make a valid comparison of revenue, it is necessary to compare anticipated revenue at the same point in time. This arises from the fact that a sum of money received or paid at the present time is worth much more in the future. Future net revenues (NR) are discounted back to their present to make possible their comparison with the present value.

The present value (PV) of future NR forthcoming at the end on n years in the future can be expressed as follow:

$$PV = NR_n \left\{ \frac{1}{(1 + i)^n} \right\}$$

where *i* is the market rate of interest.

To obtain the amortised PV, the PV of the NR is accumulated and then multiplied with an amortising factor (AF) of:

$$AF = \left\{ \frac{i(1+i)^n}{(1+i)^{n-1}} \right\}$$

Thus the amortised present value of the net revenue (AVNR) of the anticipated NR in year n can be expressed by the equation:

$$AVNR = \sum_{n-1}^{n} PV_n \left\{ \frac{[i(1+i)^n]}{[(1+i)^{n-1}]} \right\}$$

The above calculation is used to determine the optimal age of replanting. In this analysis, the annual NR is also the marginal revenue. By this method, costs and revenues can be increased or decreased by a constant amount each year without changing the optimum replanting pattern.

APPENDIX 2

YIELD PROFILE OF FRESH FRUIT BUNCH/HECTARES

Year	Yield of FFB	
	Present stand	Following stand with technology advancement
0	0	0
1	0	0
2	0	0
3	4.52	8.03
4	7.53	16.32
5	12.55	22.09
6	16.57	25.61
7	19.08	27.62
8	19.83	28.87
9	20.34	29.63
10	20.34	30.13
11	20.09	29.88
12	20.09	29.63
13	19.93	29.38
14	19.58	28.87
15	19.58	28.87
16	19.58	28.12
17	19.33	27.87
18	19.08	27.62
19	18.83	27.37
20	18.58	27.12
21	18.33	26.87
22	18.08	26.62
23	17.83	26.37
24	17.58	26.12
25	17.33	25.87
26	16.83	25.62
27	16.33	25.12
28	16.08	24.37
29	15.58	24.12
30	14.33	23.62
31	13.58	22.87
32	12.18	20.08

APPENDIX 3

THE AVERAGE PRICE OF FFB, 1981-2000 (RM/t)

Year	Average price of FFB (RM/t)
1981	169.48
1982	139.08
1983	174.80
1984	250.55
1985	180.94
1986	91.43
1987	138.10
1988	187.77
1989	162.00
1990	120.59
1991	147.97
1992	162.90
1993	143.76
1994	216.85
1995	257.10
1996	222.46
1997	264.71
1998	453.65
1999	222.15
2000	188.28
Average	**194.73**