Economics of Higher Planting Density in Oil Palm Plantations

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ABSTRACT

The aim of this paper was to study the financial returns from oil palm planted at different densities on mineral and peat soils in Malaysia. The method of analysis to achieve the mentioned objective was by the cost benefit analysis approach. Data for the analysis was obtained from oil palm planting density experiments at MPOB research stations at Hulu Paka in Terengganu and Teluk Intan in Perak.

The analysis indicated that maximum income could be obtained from a planting density of 148 palms/ha, contrary to the conventional practice of 136-148 palms/ha. On peat soil, income is still on the increase when the density is at 200 palms/ha. It is recommended that on peat higher than the conventional planting density of 136-148 palms/ha is adopted in order to maximize net present value (NPV).

INTRODUCTION

The oil palm area in Malaysia has increased relatively rapidly but the average productivity of the palms has remained relatively stagnant. The average annual yield of oil palm fresh fruit bunches (FFB) had fluctuated from 16 t/ha to 22 t/ha over the period 1975 to 2001 (MPOB, 2002a). Similarly, the average annual yield of crude palm oil per hectare ranged from 3.02 t in 1988 to 4.41 t in 1986. After 1986, the yield of oil palm in both measures has shown a gradually declining trend. One of the reasons for the problem can be attributed to the rapid expansion of the crop under a situation of increasingly scarce land availability. Hence, later expansion has tended to encroach into land areas less suitable for oil palm cultivation, giving rise to low oil palm productivity, thereby bringing down the national average productivity figure. In an MPOB survey of oil palm estates in 2002 (*Table 1*), about 16% of oil palm estates in the country had achieved as FFB yield of 25 t/ha or better. Oil palm estates yielding between 20 and 25 t/ha accounted for about 45% of the total number of estates. Low performance oil palm estates that yielded FFB output of less than

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14 t/ha accounted for 23%.

A number of efforts to study the methods for increasing oil palm yield have been undertaken by MPOB and private sector research establishments in the past. One practical approach to increasing the oil palm yield is by increasing the number of productive oil palm trees per hectare. Assuming that an oil palm can produce a constant amount of FFB per year, increasing the density of oil palms planted in a fixed area of land would increase FFB production per hectare.

However, in a biological production system such as the production of oil palm FFB, there are other factors influencing productivity. In the high density planting of oil palm, the availability of sunlight can become a limiting factor in the growth and productivity of the oil palm. If the productivity of high density oil palm farming system increases, the additional input required needs to be evaluated to examine whether the required additional input would be more than compensated by the increase in revenue gained due to the improvement in FFB output. The objective of this study is to examine the economics of high density planting in oil palm cultivation on selected soil types.

TABLE 1. PERCENTAGE OF ESTATES ACCORDING TO YIELD CLASSES

Yield (t/ha/yr)	Percent (%)
25 and above	16.2
23.00 to 24.99	10.3
20.00 to 22.99	18.1
18.00 to 19.99	12.7
16.00 to 17.99	10.8
14.00 to 15.99	8.4
Under 14	23.5
Total	**100.0**

Source: MPOB (2002b).

THEORETICAL BACKGROUND

Normal planting density usually varies according to the soil type on which the oil palms are planted. On coastal and inland soils, the planted oil palm densities are between 136 and 148 palms/ha respectively. On peat soils, however, the planting distance is normally denser, at 160 palms/ha.

The optimal planting density of the oil palm depends as mentioned largely on the availability of sunlight. As palms mature, their fronds increase in length. Consequently, as the density of oil palm per hectare is increased, there is intensification in mutual shading, reducing sunshine reaching the palms. Sunlight is an input that is most important to the growth and yield of the oil palm. From the biological point of view, Corley (1973) had developed a planting density relationship that optimizes the output of oil palm as follows:

$$D_{opt} = \frac{2241}{L^2} + 36$$

where D_{opt} = optimal density, and L = is the mean area per leaf (m^2).

The relationship indicates that optimal oil palm planting density is inversely proportional to the square of mean area per leaf - the wider the leaf area, the lower is the optimal planting density. In turn, when the mean area per leaf is small, then the optimal planting of oil palm can be denser.

The optimum planting density of oil palm can be defined in a number of ways. Donough and Betty (1991) provided three definitions for optimum oil palm planting density:

- current optimum. The oil palm planting density that provides the highest yield in any given year.
- agronomic optimum. The oil palm planting density that gives the highest cumulative FFB yield over a given period of time.
- economic optimum. Oil palm planting density that yields the most accumulated discounted profit over a given period of time.

An obvious factor related to the mean area per leaf is the age of the oil palm trees. At a young age, the mean area per leaf is small and mutual shading is minimal or non-existent. At this stage, the oil palm plantation can afford high planting density. The shading that subsequently occurs affects the FFB output over time. This in turn affects the income of the producer, a factor that is most important in the venture.

The economic aim of oil palm cultivation is chiefly to earn maximum profits for the estate owners or shareholders. In the technique of high density oil palm planting, the economic optimum density is consistent with the general aim of the business endeavour. Hence, the economic aim of high density oil palm cultivation is to maximize the present value (PV) over the economic life span of the oil palm.

A number of field trials concerned with oil palm planting density have been undertaken. Corley *et al.* (1973) found that the suitable densities of oil palm on coastal soils, good inland soils and poorer inland soils were 150, 158 and 166 palms/ha respectively. Due to the numerous density options, Corley had proposed a compromised density at 158 palms/ha.

On Riverine Alluvium soil, the economic density is in the region of 170 palms/ha for a planting cycle of 24 years. On organic soils, the economic optimal density was found to be around 180 to 190 palms/ha (Donough and Betty, 1991). Presumably these densities take into account the fact that over time, natural wastage tends to reduce the density of the oil palm over the life of the palms. Otherwise as the oil palm trees mature, the fronds would tend to overshadow each other thereby limiting sunlight penetration. Consequently, this affects productivity negatively and the trees need to be purposefully thinned down.

METHODOLOGY

In this inquiry, the economic optimum planting density of the oil palm is evaluated. Externalities are not considered since the study is mainly concerned with evaluating the financial performance over a range of oil palm planting densities. The measures used to evaluate the financial optimal density of oil palm cultivation are NPV, benefit-cost ratio (B-C ratio) and internal rate of return (IRR) over the period of the field experiments conducted by the MPOB.

The Data

The data for the analysis was obtained from MPOB research stations where oil palm planting densities are studied. The project team visited the relevant research stations and discussed with and collected data from station managers and other related personnel regarding the yield, density and cost of production for the variety of planting densities of oil palm.

RESULTS AND DISCUSSION

In this section, the various cost components in oil palm cultivation are discussed. Then the yield of FFB under different soil types and planting density regimes are analysed. Following these discussions, the financial returns of the different oil palm cultivation on different soils and planting density regimes were evaluated using the measures as mentioned earlier. From the analysis, comments are then made on the optimal planting density under different soil conditions.

Cost of Production

Costs of production are the costs involved in the operation of the plantation per unit FFB output. These costs can be divided into six components. They are development, upkeep, manuring, harvesting and collection, transport to mill and general charges.

Development costs. These are costs incurred in the preparation of the field for oil palm cultivation. The costs involved in this stage are land clearing, road construction, drainage construction, lining, planting materials, holing and planting. In peat areas, land compaction is necessary. The cost of planting per palm was found to be RM 41.65/palm. Based on the cost of establishing a palm, the cost per hectare is different with different planting densities. The costs per hectare at different planting densities are shown in *Appendix 1*.

Cost of upkeep. There are two items in this cost component, namely, weeding and pruning. The weeding cost is higher in the second year after the oil palm is planted. The pruning cost starts in the second year on inland soil and when the palms are mature on peat soil.

Cost of manuring. The manuring cost encompasses the cost of chemical fertilizer as well as its application. This cost is one of the major costs in the production of FFB. The share of this cost component is about 36% of the total annual cost.

Harvesting and collection. The harvesting and collection costs are directly dependent upon the FFB yield achieved. The cost is mainly in the form of wage payments usually based on a per tonne FFB basis. The cutter does the harvesting, while FFB collection is undertaken by another group of workers. The share of harvesting and collection works in the total cost of FFB production is about 29%.

Transport to mill. The cost of transportation to the mill is a function of the weight of FFB moved and for the distance involved in this study, the associated cost of transportation of FFB was about RM 12 on peat soil and RM 10 on inland soil.

General charges. General charges are the overhead costs, which include salaries of the manager and other staff as well as expenditures on facilities and staff official travelling. In the study, this cost was not available for the various trials. Therefore, the cost obtained from another study was used in the analysis. The costs were estimated to be RM 550/ha or RM 22.60/t.

Yield of Fresh Fruit Bunches (FFB)

In Teluk Intan where the soil is deep peat, denser than normal plantings were found to yield higher quantities of FFB. *Figure 1* shows the graphs from various oil palm planting densities for yield of FFB from 1985 to 2000. The lines show 120 palms/ha to 160 palms/ha and 200 palms/ha respectively. The higher the planting density, the 13 years of records show better yields. This was confirmed by pair-wise T-tests performed on the difference of mean yield between the indicated oil palm planting densities. For trees that had been producing over 13 years, the average yields were 21, 26 and 29 t/ha/yr for the densities of 120, 160 and 200 palms/ha respectively.

Figure 2 shows the yields of FFB from a planting density trial on inland soil. The yield data were for 12 years from 1985 until 1998 while the trial started in 1983. The first three years were the immature phase of the palms. In the trial, densities of 148 palms/ha and 171 palms/ha were found to yield the highest quantity of FFB compared to the other density regimes. The average yields for densities of 121 palms/ha, 148 palms/ha, 171 palms/ha and 216 palms/ha were 19, 22, 22 and 20 t/ha/yr, respectively. The difference in yield between the various planting densities was small. The lines in *Figure 2* indicate that the yield did not increase with the oil palm planting density.

Financial Analysis

The yield differences may not show the advantages of the different planting densities. The ultimate measure of the viability of the planting density technology in oil palm is the monetary outcome of the venture. In this section, we financially compare the performances between the different oil palm planting densities on two soil types, *i.e.*, peat and inland soils.

On peat soil, as mentioned earlier, the FFB output responded positively to the increase in oil palm density per hectare. With higher density, there will also be a need to increase agricultural labour, capital and material inputs. We are then faced with the problem of whether the mentioned increase

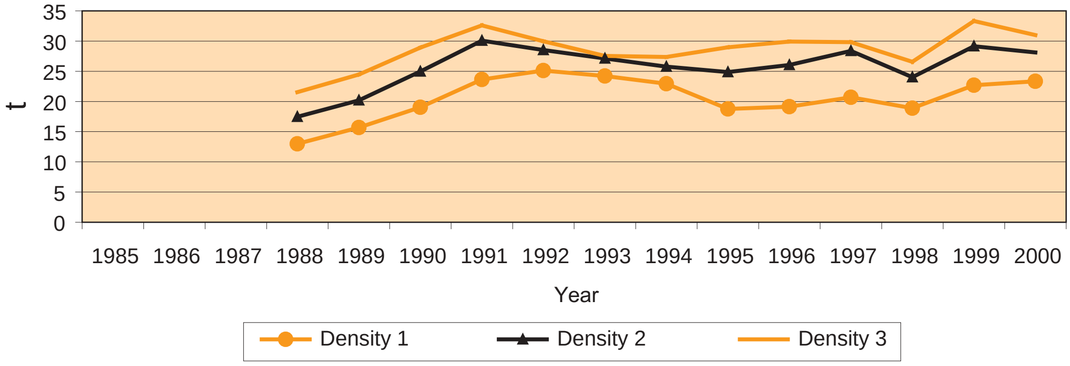

Figure 1. Oil palm yield on peat soil, Teluk Intan, Malaysia (t FFB/ha/yr).

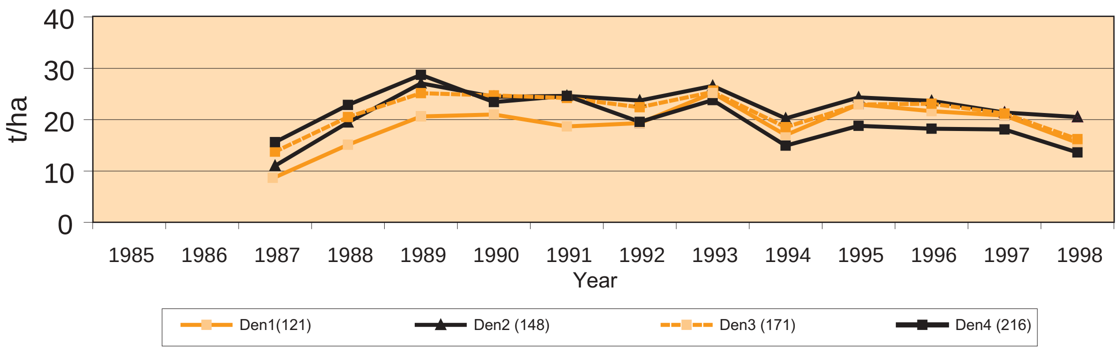

Figure 2. Yield of fresh fruit bunches on inland soil, Hulu Paka, Malaysia (t/ha).

in FFB output as a result of the denser planting distance will more than compensate for the additional cost involved. In order to evaluate the situation, we employed the financial measures of NPV, IRR and B-C ratio. We measured the financial worth of the different oil palm planting densities on the two kinds of soils. An example of the cash flow analysis for the financial performance measures is shown in *Appendix 1*. The discount rate adopted in the computation of NPV and B-C ratio was 10%. Three scenarios were examined in order to analyse the financial returns between the three planting density regimes.

Table 2 shows a summary of the results of the financial analyses performed to identify the best planting density from the financial point of view. The analysis found that at the planting density of 200 palms/ha, all the financial measures showed the highest financial return. The IRR was 27% while the NPV measure was largest at RM 17 260 with a B-C ratio of 1.75. The payback period, which was also computed, showed that there was no difference between the densities of 160 and 200 palms/ha while the payback periods were faster than oil palm cultivation at a density of 120 palms/ha.

On inland soil, the data showed that out of the four oil palm densities, the best was 148 palms/ha. The IRR, NPV and B-C ratio for oil palm on the inland soil were low as shown in *Table 3*. At 10% rate of discount, the NPV that was computed was negative. These unfavourable financial measures were obtained due to two reasons. First and most important was that the analysis covered only 16 years of the usually 25 year economic life span of the oil palm. Second was that the yield obtained was much less than what was obtained on peat soils.

TABLE 2. RESULTS OF THE CASH-FLOW ANALYSIS OF VARIOUS OIL PALM PLANTING DENSITIES ON PEAT SOIL

Financial measure	Planting density (palms/ha)		
	120	160	200
IRR (%)	21	25	27
NPV (10%) (RM)	9 310	14 542	17 260
B-C ratio (10%)	1.51	0.83	1.75
Average FFB production cost (RM/t)	98	92	93
Average FFB yield (t/ha/yr)	21	26	29
Payback period	years	years	years

TABLE 3. CASH-FLOW ANALYSIS OF OIL PALM CULTIVATION ON INLAND SOIL, AT VARIOUS PLANTING DENSITIES

Financial measure	Planting density (palms/ha)			
	121	148	171	216
IRR (%)	3	6	4	0
NPV @ 10% rate of discount	-4 916	-3 214	-4 134	-5 634
B-C ratio	0.75	0.84	0.80	0.74
Payback period (years)	15	14	15	16
Average cost of production (RM/t FFB)	130	119	127	141
Average FFB yield (t/ha/yr)	19	22	22	20

The financial indicator, NPV, was plotted against the various planting densities for oil palm on peat and inland soils as shown in *Figures 3* and *4*. On peat, the plot shows an increase in the NPV values, the highest being at 200 palms/ha. The highest point did not indicate a mathematical maximum showing that theoretically, the NPV can be increased further beyond the 200 palms/ha mark. This possibility may be explored in the future as a technique to increase oil palm productivity on peat soils.

On inland mineral soil, as indicated in *Figure 4*, there is a clear mathematical maximum at a planting density of slightly more than 148 palms/ha. This planting density has been the industry norm for a long time. At densities greater than 148 trees/ha, the NPV declines and therefore, it does not pay for planters to increase planting densities further.

The analysis of the different planting densities on inland and peat soils showed a clear indication for the oil palm planting density policy for oil palm planted on inland mineral soils. The planting density was optimal at about 148 palm/ha. Oil palm planted on peat soils pose some problems for planters on the decision of oil palm planting density. The results of the analysis show that NPV was still on the increase even at a density of 200 palm/ha. On the basis of the analysis alone, it is economically rational to increase oil palm planting density beyond 200 palm/ha.

The normal planting density practice on peat is the conventional 136-148 palms/ha (Tayeb, 2002). This practice is adopted on both peat and mineral soils. On deep

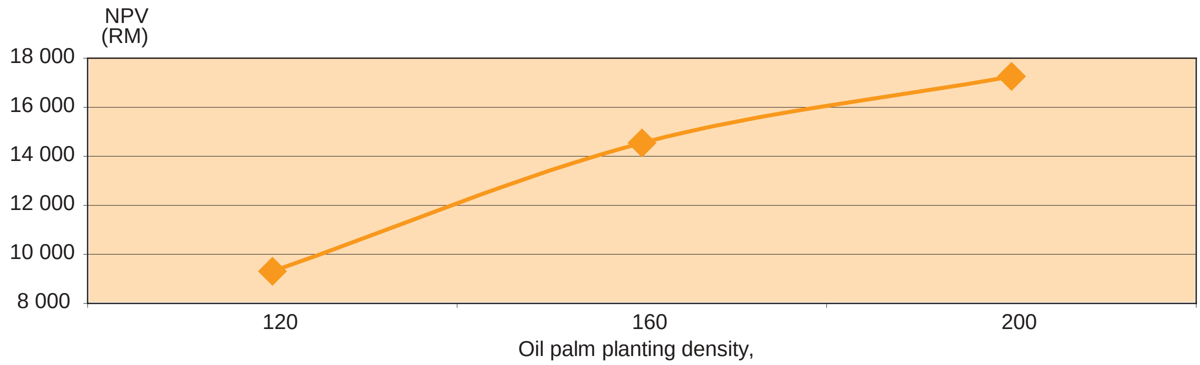

Figure 3. Net present value and oil palm planting densities, peat soil.

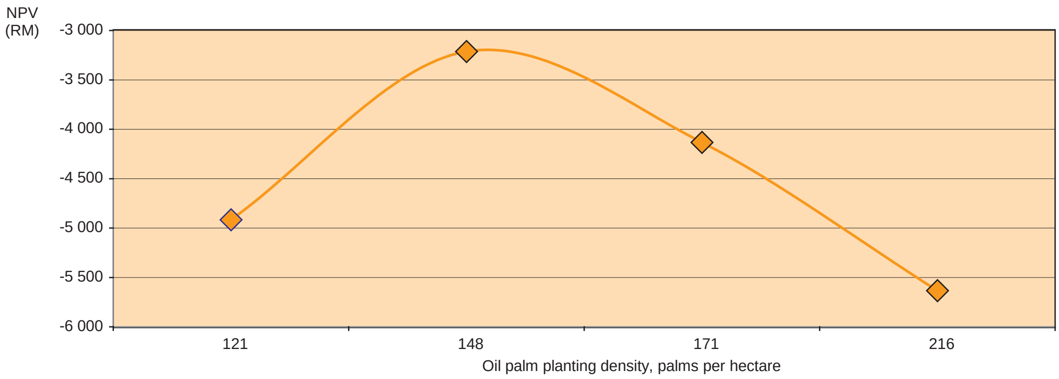

Figure 4. Net present value and oil palm planting density, inland soil.

peat, a density of 160 palms/ha is the normal system, contrary to the findings of this study, which indicated that higher density would bring more economic returns than the traditional planting density.

CONCLUSION AND RECOMMENDATIONS

This study found that on the peat soil, the density that provided the highest financial return was 200 palm/ha. However, there is an indication from the financial point of view that the earnings can be increased further. An agronomic experiment beyond 200 palms/ha is recommended. This planting density on peat soils is much higher than that used in conventional practice and therefore, income can be further improved through the practice of higher planting density.

On inland soils, this study indicated that the optimal planting density is about 148 palm/ha. As a convention in the industry, the planting density of oil palm on inland soils ranges from 136-148 palm/ha. This study indicated that a lower or higher density than 148 palms/ha does not maximize income. Maximum income is obtained when oil palm is planted at a density of 148 palm/ha, *ceteris paribus*. Unlike the results obtained on peat soils, this finding is conclusive and can be used as a guide by planters.

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REFERENCES

CORLEY, R H V (1973). Effects of plant density on growth and yield of oil palm. *Experimental Agriculture*, *9*: 169-180.

CORLEY, R H V; HEW, C K; TAM, T K and LO, K K (1973). Optimal spacing for oil palm. Paper presented in the International Oil Palm Conference. Incorporated Society of Planters, Kuala Lumpur. 16-18 November 1972. p. 52-71.

DONOUGH, C R and BETTY KWAN (1991). Oil palm planting density: results from trials in Sabah and the possible options. *The Planter*, *67 (787)*: 483-508.

MPOB (2002a). *Malaysian Oil Palm Statistics 2001*. 21st edition, Kelana Jaya, MPOB. 180 pp.

MPOB (2002b). *Palm Oil Cost of Production Survey*. Unpublished.

MOHD TAYEB, D (2002). Oil palm planting on peat - progress and future direction in R&D and commercial venture. Paper presented at the Seminar on Elevating the National Oil Palm Productivity and Recent Progress in the Management of Peat and *Ganoderma*. Hotel Equatorial, Bangi.

Appendix 1

EVALUATION OF HIGHER PLANTING DENSITY OF OIL PALM CULTIVATION
PLANTING DENSITY : 120 palms/ha

Subject/Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
			1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Revanue																		
Yield FFB (t/ha/yr)			0.00	0.00	0.00	12.99	15.68	19.05	23.65	25.11	24.21	22.95	18.77	19.13	20.69	18.90	22.69	23.33
Price FFB (RM/t)			0.00	0.00	0.00	244.02	197.09	164.99	198.61	221.51	208.07	302.05	343.12	286.05	319.51	551.03	351.52	240.51
Total revenue			**0.00**	**0.00**	**0.00**	**3 169.78**	**3 090.31**	**3 142.99**	**4 697.23**	**5 562.23**	**5 037.37**	**6 931.94**	**6 440.41**	**5 472.13**	**6 610.74**	**1 0414.42**	**7 976.07**	**5 611.20**
Costs																		
Development																		
Felling			407.55															
Collecting and burning			456.95															
Clearing tree's stumps, collecting and burning			74.10															
Main drain			309.14															
Secondary drain			54.46															
Field drain			205.86															
Culvert			350.00															
Main road			1 235.00															
Field road			743.60															
Compaction			247.00															
Lining			27.79															
Holing			120.00															
Seedling			600.00															
Planting			72.00															
Upkeep																		
Weeding			0.00	666.90	301.72	270.00	146.20	144.00	144.00	144.00	144.00	132.00	132.00	99.00	132.00	144.00	144.00	144.00
Pruning			42.75	42.75	42.75	42.75	42.75	42.75	42.75	47.25	47.25	52.50	52.50	52.50				
Maintenance of roads			0.00	0.00	0.00	0.00	65.81	260.25	549.86	672.57	340.75	0.00	0.00	15.67	199.92	206.53	160.31	291.23
Maintenance of drains			0.00	0.00	0.00	91.07	0.00	110.44	110.44	0.00	122.63	122.63	122.63	169.09	169.09	169.09	169.09	169.09
Manuring																		
Fertilizer			86.07	141.39	182.80	236.20	323.01	399.30	476.65	493.92	262.77	246.99	278.80	297.42	308.94	360.00	338.58	318.90
Fertilizer application			0	75.00	52.50	52.50	57.30	96.00	96.00	96.00	96.00	96.00	96.00	96.00	96.00	94.50	94.50	81.00
Harvesting and collection			0	0.00	0.00	233.82	282.24	342.90	425.70	451.98	435.78	413.10	337.86	344.34	372.42	340.2	408.42	419.94
Transport to mill			0	0.00	0.00	155.88	188.16	228.60	283.80	301.32	290.52	275.40	225.24	229.56	248.28	226.8	272.28	279.96
General charges			550.00	550.00	550.00	550.00	550.00	550.00	550.00	550.00	550.00	550.00	550.00	550.00	550.00	550.00	550.00	550.00
Total cost			**5 539.52**	**1 433.29**	**1 087.02**	**1 589.47**	**1 655.47**	**2 174.24**	**2 679.20**	**2 752.54**	**2 285.20**	**1 878.87**	**1 785.28**	**1 848.33**	**2 123.90**	**2 143.62**	**2 189.68**	**2 306.62**
Net revenue			**5 539.52**	**-1 433.29**	**-1 087.02**	**1 580.31**	**1 434.84**	**968.75**	**2 018.03**	**2 809.69**	**2 752.1747**	**5 053.074**	**4 655.13**	**3 623.80**	**4 486.84**	**8 270.80**	**5 786.39**	**3 304.58**
				-6 972.81	-8 059.83	-6 479.52	-6 044.68	-4 075.93	-2 057.89	751.79	3 503.97	8 557.04	13 212.17	16 835.97	21 322.81	29 593.61	35 380	38 684.59
Cum. net. revenue			**38 684.59**															
IRR			**21%**															
NPV 10%			**9 310**								8th year							
Benefit cost ratio 10%			**1.51**															
Average cost FFB RM/t			**98.39**															