Economics of High Planting Density on Rubber Smallholdings: Revisited

ABDULLAH BIN SEPIEN
Rubber Research Institute of Malaysia, Kuala Lumpur

Abstract in Bahasa Malaysia

Kertas ini cuba menganalisa kesan-kesan dari berlainan pokok dalam torehan sehektar pada perolehan, pendapatan, kos pengeluaran dan keuntungan sehektar bagi 185 pekebun-pekebun kecil persaorangan dan 149 peserta rancangan Felda di Melaka, bertujuan menunjukkan kepadatan tanaman yang sesuai bagi kebun-kebun kecil getah.

Analisa ini menunjukkan bahawa pendapatan keluarga yang paling tinggi didapati di kebun-kebun persaorangan yang mempunyai pokok-pokok dalam torehan diantara 400 dan 500 sehektar. Di kebun-kebun Felda pula apabila pokok-pokok untuk torehan diantara 350 dan 400 sehektar. Berdasarkan pada kajian yang dibuat, kertas ini mencadangkan bahawa kekerapan tanaman yang sesuai bagi kebun-kebun persaorangan adalah diantara 600 dan 750 pokok sehektar dan di-bun-kebun Felda diantara 500 dan 600 pokok sehektar.

Abstract

This paper attempts to analyse the effects of different number of trees under tapping per hectare on yield, income, cost of production and profit per hectare of 185 independent and 149 Felda (Federal Land Development A... smallholders in Melaka with the aim of indicating the range of appropriat... ing densities for rubber smallholdings.

The analysis indicates that the highest family income on independent holdings was obtained when trees under tapping were between 400 and 500 per hectare, and on Felda holdings when they were between 350 and 400 per hectare Based on these findings the paper suggests that the appropriate planting density for independent holding is between 600 and 750 trees and for Felda holdings between 500 and 600 trees per hectare.

In the rubber smallholding (farm of less than 40 ha) situation where the farms are small, approximately 2.0 ha, a feasible means of increasing a smallholder's

income is to obtain the maximum productivity from this limited input factor. To achieve this, it is essential for the smallholder to make the right decisions as to the type of trees and how many trees to plant per hectare (planting density), how much labour and other associated input factors including fertiliser, weedicides and pesticides to use.

While decisions concerning the use of labour and other associated inputs are short-term in nature and they could be made whenever necessary, the choice of planting materials and planting densities are long-term decisions, which, once made and implemented would be difficult to alter. Thus it is imperative that smallholders make the right choice of planting materials and planting density.

This paper is concerned with the choice of planting densities on rubber smallholdings. It attempts to show the differences in average annual yield (output per hectare), gross income, cost of production, family income and profit per hectare obtained from smallholdings with different number of trees in tapping per hectare with the aims of indicating the appropriate planting densities on smallholdings.

METHODS AND DATA'

The data used for this analysis were obtained from 185 independent smallholders in the districts of Jasin, Alor Gajah and Melaka Tengah, and 149 Felda participants selected from a total of 782 from Hutan Percha, Kemendore and Machap Felda land settlement schemes.

All the smallholders selected had similar planting materials that were 10 to 15 years old. Additionally, the holdings selected were located in areas of minimum variation in soil types and environmental conditions. This selection minimises the variation in their productivity with respect to these factors, thus allowing for better comparison in other respects. In Felda holdings there was also greater uniformity in the maintenance of the holdings since they come under the supervision of the Felda management.

The data relating to the output, incomes, loan repayment, fertiliser and labour utilisation of Felda smallholders were obtained from records kept by the respective scheme managers; while data on the independent smallholders were based on their estimates. The number of trees in tapping, the number of trees standing and the number of diseased trees were obtained by means of a field count of each holding.

There are a number of important differences between the independent and Felda smallholders. They differ significantly in respect of farm sizes, planting materials, number of trees in tapping per hectare, yield, incomes, costs of production and management. Thus separate analyses had to be made for each smallholder group.

The planting materials used on independent holdings were approximately 68 percent CS (clonal seedling) rubber with the remainder comprising a variety of budded trees including RRIM 600, 605 and 625, Tjir 1. All the Felda holdings were budded. They were planted with either a single or a combination of RRIM 605, 623 and 513, PB 86, PR 107 and GT 1 clones.

The average number of trees in tapping differs widely between the two categories of smallholdings. On independent holdings it ranges from 100 to 986 trees per hectare. On Felda holdings the range is smaller, from 157 to 385 trees. In consequence different 'class intervals' were used: 100 for independent holdings and 30 for Felda holdings *(Table 1)*.

Rubber yield was measured in terms of latex, scrap (tree lace and cuplump), and as the sum total of the dry weight of latex and scrap (which after the scrap has been homogenised into its latex equivalent by using the ratio of scrap to latex prices).

Labour input used in the analysis was standardised into 8-hour equivalent man-days. Cost of family labour was derived by multiplying the family labour input by its opportunity cost which is based on the average wage a smallholder expects to obtain from an alternative job and the probability of obtaining that job[1]. No hired labour was used by any of the smallholders studied.

As the smallholders used more than one type of fertilisers the amount used in the analysis was standardised into CCM 99 (Chemical Company of Malaysia Compound No. 99) equivalent by using a ratio of their prices.

Loan repayment (Felda smallholders only) includes CAC (Consolidated annual charges) which comprises land rent, survey fees and other charges due to the state government. At the time of the study all Felda smallholders had almost completed their loan repayments.

Equipment depreciation includes depreciation of harvesting and maintenance equipment, and of vehicles.

Gross income comprises of all income from rubber, while *family income* is the gross income less all costs of production except the cost of family labour. When the cost of the family labour is subtracted from the family income, the residual is called *profit*.

Ideally, an economic assessment of this nature should consider the returns to investment based on various economic measures such as the NPV (Net Present Value), IRR (Internal Rate of Return), and benefit-cost ratio. In order to perform these analyses, time-series and cross-sectional data for each planting density are required. As the required data were not available, the analysis was based

on only one year's (1975) cross-sectional data. All the costs and incomes were based on input and output prices prevailing for that year.

It is well known that rubber-yield varies with the age of trees. Thus age of the trees selected could affect the analysis substantially. To minimise these effects all the holdings selected had trees that were between 10 to 15 years old, when most of them would have attained their maximum yield.

Due to the limitations of the data caution should be exercised when interpreting the results of this analysis for policy purposes. At best they can only serve as rough indicators or guidelines for policies pertaining to planting densities.

RESULTS AND DISCUSSIONS

The results are discussed under three sections: (a) yield and gross income; (b) cost of production; and (c) family income and profit.

Yield and Gross Income

Tables 1 and *2* show the average annual yield, gross income, production cost, family income and profit per hectare in relation to trees in tapping on independent and Felda holdings respectively. (For details of items in *Tables 1, 2, 3* and *4* see *Appendices 1, 2, 3* and *4*, respectively).

The average annual yield per hectare of independent holdings increased by more than 100% from approximately 740 to 1,690 kg per hectare when the number of trees in tapping increased from about 200 to between 401 to 500 trees per hectare; and to about 2 300 kg when the trees in tapping per hectare increased further to 501 – 600 *(Table 1)*. Although the yield was highest (approximately 3,600 kg) for holdings with more than 601 trees in tapping per hectare, it was not considered in this analysis because there were only two holdings in this category *(Table 1)*.

Thus the highest average annual gross income on independent holdings was approximately $2,270 per hectare, obtained when the number of trees in tapping was between 501 to 600.

On Felda holdings, the average annual yield increased steadily with increasing number of trees in tapping per hectare. It attained a maximum of approximately 1,900 kg with 301 – 330 trees in tapping per hectare and declined to approximately 1,880 kg when the trees in tapping exceeded 331 per hectare *(Table 2)*. Thus the highest average annual gross income of approximately $2,200 per hectare was obtained when the number of trees in tapping was between 301 and 330 *(Table 2)*.

TABLE 1. AVERAGE ANNUAL YIELD, INCOME AND COST OF PRODUCTION OF INDEPENDENT SMALLHOLDERS PER HECTARE BY TREES IN TAPPING PER HECTARE

	Trees in tapping per hectare						
	⩽ 200	201–300	301–400	401–500	501–600	⩾601	All
Sample (no.)	9(4.86)[a]	55(29.73)	74(40.00)	37(20.00)	8(4.33)	2(1.08)	185(100.00)
Yield (kg)	736.46	1 214.93	1 510.92	1 686.48	2 276.36	2 565.97	1 464.87
Gross income (ringgit)	695.14	1 136.06	1 417.93	1 595.51	2 267.84	2 411.67	1 382.18
Total cost (ringgit)	522.24	586.34	688.23	822.43	791.52	1 210.97	686.82
Family income[b] (ringgit)	583.14	967.69	1 208.06	1 374.79	2 012.60	2 093.84	1 183.91
Profit[c] (ringgit)	172.90	549.72	729.70	774.08	1 476.32	1 200.70	695.36

[a]Figures within brackets are proportions of holdings with different number of trees in tapping per hectare (%)
[b]Family income in gross income less all costs except the cost of family labour.
[c]Profit is gross income less total cost.

TABLE 2. AVERAGE ANNUAL YIELD, INCOME AND COST OF PRODUCTION OF FELDA SMALLHOLDERS PER HECTARE BY TREES IN TAPPING PER HECTARE

	Trees in tapping per hectare							
	⩽ 180	181–210	[illegible]240	241–270	271–300	301–330	⩾ 331	All
Sample (no.)	7(4.69)[a]	12(8.05)	[illegible]3)	29(19.46)	22(14.77)	27(18.13)	22(14.77)	149(100.00)
Yield (kg)	1 557.46	1 416.64	1 774.88	1 743.52	1 808.49	1 899.69	1 880.89	1 772.94
Gross income (ringgit)	1 799.23	1 614.77	2 043.24	1 987.33	2 064.00	2 197.75	2 193.37	2 039.62
Total cost (ringgit)	541.26	427.81	516.67	511.7[illegible]	528.87	581.34	806.34	566.00
Family income[b] (ringgit)	1 602.98	1 346.49	1 812.60	1 731.19	1 803.63	1 957.70	1 959.59	1 796.04
Profit[c] (ringgit)	1 257.97	1 186.96	1 526.57	1 475.60	1 535.13	1 616.41	1 387.03	1 473.62

[a]Figures within brackets are proportions of holding with different number of trees in tapping per hectare (%).
[b]Family income is gross income less all costs except the cost of family labour.
[c]Profit is gross income less total cost.

TABLE 3. YIELD, INCOME AND COST OF PRODUCTION OF INDEPENDENT SMALLHOLDERS PER KILOGRAMME BY TREES IN TAPPING PER HECTARE

	Trees in tapping per hectare						
	⩽ 200	201–300	301–400	401–500	501–600	⩾ 601	All
Sample (no.)	9	55	74	37	8	2	185
Yield (kg)	736.45	1 214.93	1 510.92	1 686.48	2 276.36	2 565.97	1 464.87
Gross income (ringgit)	0.94	0.94	0.94	0.95	1.00	0.94	0.94
Total cost (ringgit)	0.75	0.53	0.53	0.52	0.47	0.94	0.53
Family income[a] (ringgit)	0.77	0.79	0.78	0.81	0.86	0.81	0.79
Profit[b] (ringgit)	0.19	0.41	0.41	0.43	0.53	0.45	0.41

[a]Family income is gross income less all costs except the cost of family labour.
[b]Profit is gross income less total cost.

Cost of Production

The annual average cost of production includes the cost of family labour, chemicals (fertilisers, weedicides, pesticides and acids), depreciation of harvesting and maintenance equipment, quit rent and loan repayments for Felda smallholders (See *Appendices 1* and *2)*.

More trees in tapping per hectare necessarily require more of almost all inputs especially harvesting and maintenance labour *(Appendices 1* and *2)*. Thus the average cost of production per hectare per annum was also more. On independent holdings it increased from about $522 to $822 (an increase of approximately 57%) when trees in tapping increased from approximately 200 to 401 – 500. Similarly, on Felda holdings it increased from approximately $428 to $581 per hectare (an increase of approximately 36%) when the trees in tapping increased from 181 – 210 to 301 – 330 *(Table 2)*.

When the average cost of production per kilogramme was examined, it was found that on independent holdings, it declined from approximately 75 ct for holdings with more than 200 trees in tapping per hectare to a minimum of 47 ct for holdings with 501 – 600 trees, a decrease of approximately 37% *(Table 3)*. This substantial decrease in cost is largely due to the savings in the overhead costs including the costs of depreciation, quit rent and cost of labour due to increased production. This suggests that there is some evidence of economics of size in rubber production.

On Felda holdings, although there was no clear trend, the data suggested that the average cost of production per kilogramme decreased from 39 ct for holdings with ≤ 180 trees in tapping to 30 ct for those with 241 – 270 trees in tapping per hectare. However, it increased to 47 ct for holdings with >331 trees in tapping per hectare. This relatively smaller cost savings on Felda holdings when compared to independent holdings is probably because the production of Felda holdings was already high and consequently the benefits from economies of size were minimal.

Family Income and Profit

The highest family income ($2,012) and profit ($1,476) per hectare per annum on independent holdings were attained by smallholders who had 501 – 600 trees in tapping per hectare *(Table 1)*. Although the highest gross income on Felda holdings was realised on holdings with 301 – 300 trees in tapping, after adjusting for all the production costs except the cost of family labour, the highest family income approximately $1,960, was achieved by holdings with more than 330 trees in tapping per hectare. However, due to the increased costs of family labour, the profit obtained was approximately $200 lower than that from holdings with 301 – 331 trees in tapping (approximately $1,600).

On per kilogramme basis, the highest family income (86 ct) and profit (53 ct) on independent holdings were also attained on holdings with 501 – 600 trees in tapping per hectare *(Table 3)*. Due to the lack of a clear trend in the cost of production per kilogramme, as mentioned earlier, the family income and profit per kilogramme on Felda holdings also tended to fluctuate with the number of trees in tapping per hectare *(Table 4)*.

CONCLUSIONS

Although the analysis suggests that the highest family income and profit per hectare were realised with 501 – 600 trees in tapping per hectare, holdings with such high stands may not be practicable to manage due to possible agronomic problems, including those of pests and diseases. Moreover strong reliance cannot be placed on the results obtained from these holdings because there were only eight of them available for the analysis *(Table 1)*.

Thus this analysis suggests that independent holdings with trees that are 10 – 15 years old should have an average of 401 – 500 trees in tapping per hectare in order to obtain the maximum benefit from the land available. With 401 – 500 trees in tapping an average family income of approximately $1 375 and an average profit of about $775 per hectare per year can be obtained *(Table 1)*. This is so assuming the input and output prices prevailing in 1975. With higher current farm-gate rubber prices the family income and profit are likely to be substantially more. There is no difference in the number of trees in tapping per hectare irrespective of whether the independent smallholders maximise family income or profit.

In order to have between 401 to 500 trees in tapping per hectare, independent holdings should initially have an initial stand of between 600 to 750 trees per hectare (or approximately 240 to 000 trees per acre). This is after taking into account a 10% mortality rate, which is typically experienced on smallholdings after the 10th to 15th year, and also for the fact that 75% of trees surviving are in tapping.

On Felda holdings, the highest family income of approximately $1960 was obtained from holdings with more than 300 trees in tapping *(Table 2)*. The average number of trees in tapping per hectare for the hoidings in this category was approximately 351 *(Appendix 2)*. Thus assuming that smallholders maximise family incomes, the optimum stand on Felda holdings should be between 350 – 400 trees in tapping per hectare. To be able to maintain 350 – 400 trees in tapping per hectare at the 10th to the 15th year, Felda holdings should have an initial stand of 500 to 600 trees per hectare (200 to 240 per acre). This suggestion taken into account the tree mortality rate as well as the proportion of trees normally in tapping against the number of trees surviving on the holding.

TABLE 4. YIELD, INCOME AND COST OF PRODUCTION OF FELDA SMALLHOLDERS PER KILOGRAMME BY TREES IN TAPPING PER HECTARE

	Trees in tapping per hectare							
	≤180	181–210	211–240	241–270	271–300	301–330	≥ 331	All
Sample (no.)	7	12	30	29	22	27	22	149
Yield (kg)	1 557.46	1 416.64	1 774.88	1 743.52	1 808.49	1 899.69	1 880.89	1 772.94
Gross income (ringgit)	1.16	1.14	1.15	1.14	1.14	1.16	1.17	1.15
Total cost (ringgit)	0.39	0.32	0.31	0.30	0.31	0.33	0.47	0.34
Family income[a] (ringgit)	1.03	0.94	1.02	0.90	0.98	1.02	1.03	1.00
Profit[b] (ringgit)	0.77	0.82	0.84	0.84	0.83	0.83	0.70	0.81

[a]Family income is gross income less all costs except the cost of family labour.
[b]Profit is gross income less total cost.

However, in the case where profit is the maximand because labour is a constraint, the optimum number of trees in tapping for 10 – 15 years old Felda schemes ranges from 301 to 300, and this requires an initial stand of approximately 450 – 500 trees per hectare (180 – 200 trees per acre).

These suggestions here are consistent with those recommended earlier by Barlow and Lim[2], Barlow[3] and Lim[4] and are considered to be appropriate for respective smallholdings because yield from land, a limited resource, can be maximised.

In addition, it is better to have more, rather than less trees in a holding, since it takes a minimum of six years from initial planting before trees can be productive. A greater number of trees allows greater flexibility for the smallholder to adjust his resource allocation with respect to changes in inputs and output prices. This is a crucial factor because of the long gestation period of the rubber crop. For example, if rubber prices are high, a smallholder may tap all the trees in his holdings, and conversely, if rubber prices are low, he may tap only the most productive trees.

The advantage of these suggestions is that it does not impinge on any constraints that might exist on land, especially with respect to the availability of fresh agricultural land for Felda's development.

If the suggested planting density is feasible it may not be necessary for Felda to increase the size of holdings beyond the average of 3.0 ha in order to raise the smallholders' incomes on new schemes. Thus it is suggested that with approximately 1,200 budded trees in tapping per holding and adequate fertilisation of the trees, a smallholder with a three hectare holding should be able to improve his income levels, provided relative factors and product price do not change markedly.

ACKNOWLEDGEMENT

The author is grateful to Encik Rawian bin Haji Ahmad for his assistance in the preparation of the tables; and to Dr. T. Y. Pee for his comments.

REFERENCES

1. Sen, A.K. (1964). 'Size of Holding and Productivity', *The Economic Weekly, 16*, 323.

2. Barlow C. and Lim, S.C. (1967). 'Effect of Density Planting on the Growth, Yield and Economic Exploitation of *Hevea brasiliensis* Part II, The Effect on Profit', *J. Rubb. Res. Inst. Malaya 20(1)*, 44.

3. Barlow, C. (1975). 'Development and Equality in the Natural Rubber Industry', paper discussed at a work-in-progress seminar. Department of Economics, Research School of Pacific Studies, The Australian National University.

4. Lim, S.C. (1976). *Land Development Schemes in Peninsular Malaysia: A Study of Benefits and Costs*. Kuala Lumpur: Rubber Research Institute of Malaysia.

DISCUSSION

There is no discussion for this paper.

YIELD, INCOME AND COST OF PRODUCTION OF INDEPENDENT SMALLHOLDERS PER HECTARE BY TREES IN TAPPING PER HECTARE

	Trees in tapping per hectare							F-Statistics[a] (d.f. 6 178)
	⩽ 200	201–300	301–400	401–500	501–600	⩾ 601	All	
Sample (no.)	9	55	74	37	8	2	185	
Average holding size (ha)	1.29	1.15	1.09	0.98	0.70	0.45	1.07	2.08
Yield (kg)								
Latex	663.29	1 103.05	1 387.98	1 569.24	2 129.69	2 381.90	1 347.09	9.28**
Scrap	155.94	238.45	262.04	249.87	312.58	392.32	251.03	1.83
Total	736.45	1 214.93	1 510.92	1 686.48	2 276.36	2 565.97	1 464.87	9.26**
Gross income (ringgit)								
Latex	625.50	1 029.45	1 301.83	1 486.36	2 107.86	2 236.55	1 269.81	10.22**
Scrap	69.64	106.61	116.10	110.15	158.98	175.12	112.37	2.43*
Total	695.14	1 136.06	1 417.93	1 596.51	2 267.84	2 411.67	1 382.18	10.42**
Physical inputs:								
No. of trees in holding	330.99	389.43	449.79	557.99	641.91	1 172.84	463.83	82.28**
No. of trees in tapping	169.01	270.43	346.89	446.23	543.13	856.48	349.37	418.39**
Labour (mandays)								
Harvesting	164.88	169.11	193.34	238.78	220.69	381.82	197.06	2.56*
Maintenance	2.72	2.85	3.57	4.97	2.93	4.07	3.57	1.16
Total	167.60	171.96	196.91	243.75	223 62	385.89	200.63	2.59*
Chemicals								
Fertilisers (kg)	21.95	64.26	94.09	57.75	25.00	163.27	72.21	2.17*
Costs (ringgit)								
Labour								
Harvesting	403.74	410.88	469.63	588.38	529.27	883.76	479.77	2.00
Maintenance	6.50	7.08	8.72	12.33	7.03	9.38	8.78	1.14
Total	410.24	417.96	478.35	600.72	536.29	893.14	488.55	2.02
Chemicals								
Fertilisers	8.23	27.33	38.19	26.13	7.50	80.00	30.22	2.15*
Weedicides and pesticides	2.33	6.77	6.99	7.41	16.71	24.49	7.39	1.02
Acids	10.98	18.26	23.00	25.96	35.31	39.25	22.30	9.19**
Total	21.54	52.36	68.18	59.50	59.52	143.74	59.91	2.92**
Equipment depreciation	45.06	63.15	77.27	92.27	118.54	101.40	76.55	2.39*
Other costs[b]	45.40	52.87	64.43	69.94	77.17	72.69	61.81	2.17*
Total cost (ringgit)	522.24	586.34	688.23	822.43	791.52	1 210.97	686.82	3.35**
Family income[c] (ringgit)	583.14	967.69	1 208.06	1 374.79	2 012.60	2 093.84	1 183.91	9.26**
Profit (gross margin)[d] (ringgit)	172.90	549.72	729.70	774.08	1 476.32	1 200.70	695.36	4.94**

[a]F-Statistics of Analysis of Variance testing for differences and between within number of trees in tapping per hectare. Levels of significance: *5% and **1%.

[b]Includes land rent (quit rent), licence fees, cost of processing equipment (independent smallholders only).

[c]Family income is gross income less all costs except the cost of family labour.

[d]Profit is gross income less total cost.

APPENDIX 2

YIELD, INCOME AND COST OF PRODUCTION OF FELDA SMALLHOLDERS PER HECTARE BY TREES IN TAPPING PER HECTARE

	Trees in tapping per hectare								F-Statistics[a] (d.f. 6,142)
	≤180	181–210	211–240	241–270	271–300	301–330	≥ 331	All	
Sample (no.)	7	12	30	29	22	27	22	149	
Average holding size (ha)	3.19	2.87	3.09	3.03	3.00	2.90	2.79	2.97	1.07
Yield (kg):									
Latex	1 399.62	1 268.96	1 563.43	1 566.50	1 614.31	1 700.46	1 678.09	1 581.89	4.13**
Scrap	368.33	334.16	503.05	401.49	419.92	445.50	432.43	430.22	1.17
Total	1 557.46	1 416.64	1 774.88	1 743.52	1 808.49	1 899.69	1 880.89	1 772.94	3.67**
Gross income (ringgit)									
Latex	1 622.87	1 452.02	1 808.38	1 791.75	1 850.08	1 973.31	1 963.68	1 826.70	5.22**
Scrap	176.36	162.75	234.86	195.58	213.92	224.44	229.69	212.92	1.21
Total	1 799.23	1 614.77	2 043.24	1 987.33	2 064.00	2 197.75	2 193.37	2 039.62	4.75**
Physical inputs:									
No. of trees in holding	293.56	307.77	337.02	344.83	365.92	382.68	410.87	357.59	30.94**
No. of trees in tapping	161.90	196.89	227.15	254.47	284.43	314.46	350.59	269.47	642.82**
Labour (mandays)									
Harvesting	132.64	79.44	108.22	114.66	117.86	114.62	144.57	116.25	2.64*
Maintenance	3.57	8.07	10.99	11.34	6.54	7.86	7.95	8.80	0.87
Total	136.21	87.51	119.21	126.00	124.40	122.48	152.52	125.05	2.33*
Chemicals									
Fertilisers (kg)	203.32	291.67	194.76	273.31	298.98	254.89	257.39	253.78	2.50*
Costs (ringgit)									
Loan repayment[b]	48.79	68.69	78.92	69.53	59.29	57.32	51.50	63.99	1.46
Labour									
Harvesting	335.04	145.58	254.63	233.61	255.90	321.43	551.92	301.72	3.73**
Maintenance	9.97	13.96	31.39	21.98	12.59	19.86	20.65	20.70	0.50
Total	345.01	159.54	286.02	255.59	268.49	341.29	572.57	322.42	3.47**
Chemicals									
Fertilisers	91.65	131.49	87.73	123.26	134.93	115.16	116.46	114.54	2.52*
Weedicides and pesticides	15.53	16.82	17.39	20.22	17.32	17.52	11.49	16.95	0.40
Acids									
Total	107.18	148.31	105.12	143.48	152.25	132.68	127.95	131.49	2.58*
Equipment depreciation	40.28	51.27	46.61	43.13	48.84	50.05	54.32	48.10	0.46
Total cost (ringgit)	541.26	427.81	516.67	511.73	528.87	581.34	806.34	566.00	3.39**
Family income[c] (ringgit)	1 602.98	1 346.49	1 812.60	1 731.19	1 803.63	1 957.70	1 959.59	1 796.05	4.98**
Profit (gross margin)[d] (ringgit)	1 257.97	1 186.96	1 526.57	1 475.60	1 535.13	1 616.41	1 387.03	1 473.62	1.56

[a] F-Statistics of Analysis of Variance testing for differences between and within number of trees in tapping per hectare. Levels of significance: * 5% and ** 1%.

[b] Includes CAC (annual consolidated charges) which comprises land rent, survey fees and other charges due to state government (Felda smallholders only).

[c] Family income is gross income less all costs except the cost of family labour.

[d] Profit is gross income less total cost.

APPENDIX 3

YIELD, INCOME AND COST OF PRODUCTION OF INDEPENDENT SMALLHOLDERS PER KILOGRAMME BY TREES IN TAPPING PER HECTARE

	Trees in tapping per hectare							F-Statistics[a] (d.f. 6,178)
	⩽ 200	201–300	301–400	401–500	501–600	⩾ 601	All	
Sample (no.)	9	55	74	37	8	2	185	
Average holding size (ha)	1.29	1.15	1.09	0.98	0.70	0.45	1.07	2.08
Yield (kg)	736.45	1 214.93	1 510.92	1 686.48	2 276.36	2 565.97	1 464.87	9.26**
Gross income (ringgit)	0.94	0.94	0.94	0.95	1.00	0.94	0.94	10.42**
Physical inputs:								
No. of trees in holding	330.99	389.43	449.79	557.99	641.91	1 172.84	463.83	82.28**
No. of trees in tapping	169.01	270.43	346.89	446.23	543.13	856.48	349.37	418.39**
Labour (mandays)								
Harvesting	0.24	0.15	0.15	0.15	0.13	0.16	0.15	1.33
Maintenance								
Total	0.24	0.15	0.15	0.15	0.13	0.16	0.15	1.32
Chemicals								
Fertilisers (kg.)	0.02	0.06	0.06	0.04	0.01	0.04	0.05	0.96
Costs (ringgit)								
Labour								
Harvesting	0.57	0.37	0.36	0.37	0.33	0.36	0.37	1.16
Maintenance	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.33
Total	0.58	0.38	0.37	0.38	0.33	0.36	0.38	1.14
Chemicals								
Fertilisers	0.01	0.02	0.03	0.02	0.00	0.02	0.02	0.82
Weedicides and pesticides	0.01	0.02	0.02	0.01	0.01	0.02	0.02	0.17
Acids	0.02	0.02	0.03	0.02	0.02	0.03	0.02	1.45
Total	0.03	0.04	0.05	0.03	0.03	0.05	0.04	0.68
Equipment depreciation	0.07	0.06	0.06	0.06	0.07	0.05	0.06	0.23
Other costs[b]	0.07	0.05	0.05	0.05	0.04	0.03	0.05	2.16*
Total cost (ringgit)	0.75	0.53	0.53	0.52	0.47	0.49	0.53	1.04
Family income[c] (ringgit)	0.78	0.79	0.78	0.81	0.92	0.82	0.80	2.12*
Profit (gross margin)[d] (ringgit)	0.20	0.41	0.42	0.43	0.58	0.41	0.45	1.37

[a] F-Statictics of Analysis of Variance testing for differences between and within number of trees in tapping per hectare. Levels of significance: *5% and **1%.

[b] Includes land rent (quit rent), licience fees, cost of processing equipment (Independent smallholders only).

[c] Family income is gross income less all costs except the cost of family labour.

[d] Profit is gross income less total cost.

APPENDIX 4

YIELD, INCOME AND COST OF PRODUCTION OF FELDA SMALLHOLDERS PER KILOGRAMME BY TREES IN TAPPING PER HECTARE

	Trees in tapping per hectare								F-Statistics[a] (d.f. 6,142)
	⩽ 180	181–210	211–240	241–270	271–300	301–330	⩾ 331	All	
Sample (no.)	7	12	30	29	22	27	22	149	
Average holding size (ha)	3.19	2.87	3.09	3.03	3.00	2.90	2.79	2.97	1.07
Yield (kg):	1 557.46	1 416.64	1 774.88	1 743.52	1 808.49	1 899.69	1 880.89	1 772.94	3.67**
Gross income (ringgit)	1.16	1.14	1.15	1.14	1.14	1.16	1.17	1.15	4.75**
Physical inputs:									
No. of trees in holding	293.56	307.77	337.02	344.83	365.92	382.68	410.87	357.59	30.94**
No. of trees in tapping	161.90	196.89	227.15	254.47	284.43	314.46	350.59	269.47	642.82**
Labour (man-days)									
Harvesting	0.09	0.06	0.06	0.07	0.07	0.05	0.08	0.07	1.45
Maintenance									
Total	0.09	0.07	0.07	0.07	0.07	0.07	0.09	0.07	1.19
Chemicals									
Fertilisers (kg)	0.14	0.23	0.12	0.16	0.17	0.15	0.14	0.15	2.85**
Loan repayment[b]	0.03	0.05	0.04	0.04	0.04	0.03	0.03	0.04	2.28*
Labour									
Harvesting	0.25	0.11	0.16	0.14	0.14	0.18	0.32	0.18	2.63*
Maintenance	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.44
Total	0.26	0.12	0.18	0.15	0.15	0.19	0.33	0.19	2.40*
Chemicals									
Fertilisers	0.06	0.10	0.05	0.07	0.08	0.07	0.07	0.07	2.84**
Weedicides and pesticides	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.55
Acids									
Total	0.07	0.11	0.06	0.08	0.09	0.08	0.08	0.08	3.33**
Equipment depreciation	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.80
Total cost (ringgit)	0.39	0.32	0.31	0.30	0.31	0.33	0.47	0.34	1.73
Family income[c] (ringgit)	1.03	0.94	1.02	0.99	1.00	1.03	1.04	1.01	4.01**
Profit (gross margin)[d] (ringgit)	0.77	0.82	0.84	0.84	0.85	0.84	0.71	0.82	1.63

[a] F-Statistics of Analysis of Variance testing for difference between and within number of trees in tapping per hectare. Levels of significance: *5% and **1%.

[b] Includes CAC (annual consolidated charges) which comprises land rent, survey fees and other charges due to state government (Felda smallholders only).

[c] Family income is gross income less all costs except the cost of family labour.

[d] Profit is gross income less total cost.