ADOPTION OF COCONUT-BASED INTERCROPPING SYSTEMS IN SRI LANKA: THE FALLACY OF CONVENTIONAL WISDOM ON ECONOMIC PROFITABILITY

By

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ABSTRACT

Despite the concerted efforts of successive governments in Sri Lanka to popularize coconut-based intercropping (CBI) systems, an intensive land use alternative to traditional less intensive coconut monocropping, its adoption by farmers is as low as 25% of the agronomically potential area of 100,000 ha. Although the adoption of an innovation is influenced by a range of determinants which can be broadly categorized as technical, economic, institutional and personal/social, economic profitability of the technology itself is one of the key determinants influencing its adoption. This study assesses the economics of widely practiced five different CBI systems vis-a-vis coconut monocropping, employing five economic indicators, namely Total Gross Margin (TGM), Net Present Value (NPV), Benefit-Cost Ratio (BCR), returns to labor and returns to capital. Data were collected by a field survey of 113 intercroppers and 37 monocroppers conducted from March to May 1995 in three main coconut growing districts in Sri Lanka, namely: Gampaha; Kurunegala; and, Puttalam. Results revealed that all the CBI systems give higher returns per hectare than coconut monocrops, though some of the indicators, namely BCR and returns to variable costs, are reasonably attractive for monocrop coconuts, albeit they are less than for some CBI systems. The study concluded that the low rate of adoption of CBI systems is not a problem of low profitability. Hence, it is worthwhile to explore the other factors typically influencing the adoption of production technologies to find out the reasons for low adoption of CBI

INTRODUCTION

Coconut is indispensable to Sri Lanka mainly because of its intimate integration into the daily diet of Sri Lankans. The coconut industry contributes about 2.7 and 3.3%, to the Gross Domestic Product (GDP) and to export earnings, respectively, while providing livelihood for some 400,000 rural families (Liyanage, 1997). As is well known, coconuts are cultivated predominantly as a monocrop in almost all coconut growing countries in the world including Sri Lanka. Since coconuts have to be planted at wider spacing to permit the canopy growth at maturity (Figure 1), monocrop coconuts utilize bio-physical resources sub-optimally. A mature coconut palm in a pure coconut stand utilizes only about 25% of the soil mass, leaving some 75% of the soil unutilized or under utilized (Fernando, 1997). A mature coconut palm during the 6-hour peak brightest period of the day (i.e. 10:00 to 16:00 hours) intercepts effectively only about 44% of the total solar radiation, the remaining 56% of solar radiation being unutilized (Nair and Balakrishnan, 1976). In terms of land use, coconut is the largest plantation crop occupying 416,000 ha which is about 20% of nation's cultivable lands, and is approximately equal to the collective area occupied by tea and rubber, the other two major plantation crops. Inefficient land use by monocrop coconuts involves a foregone opportunity cost of an intensive land use alternative. Intercropping monoculture coconut lands with annuals, semi-perennials and perennials, raising livestock or intercropping-livestock integration under coconuts intensify the less efficient land use of coconut monocropping, thereby raising farmer's income. Despite state efforts in terms of providing subsidies, low-interest loans, extension

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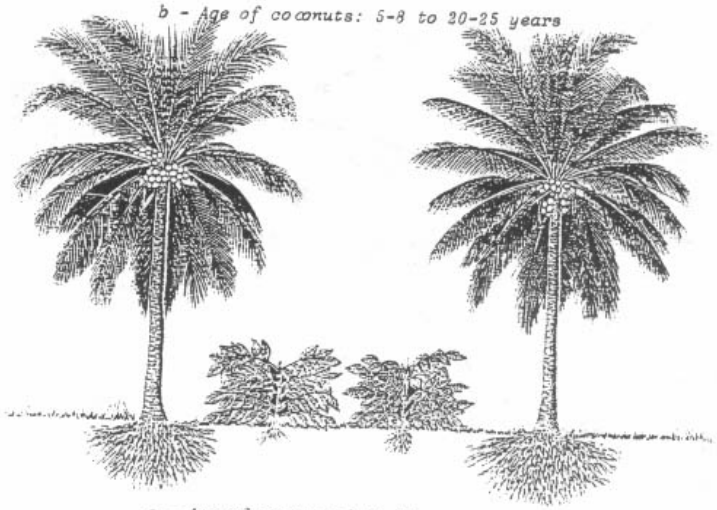
support, etc. to popularize coconut-based intercropping (CBI) over two decades, its adoption by farmers is still as low as 25% of the agronomically potential area of 100,000 ha.

Figure 1. Structure of coconut canopy at different ages

a - Age of coconuts: 1 to < 5-8 years

b - Age of coconuts: 5-8 to 20-25 years



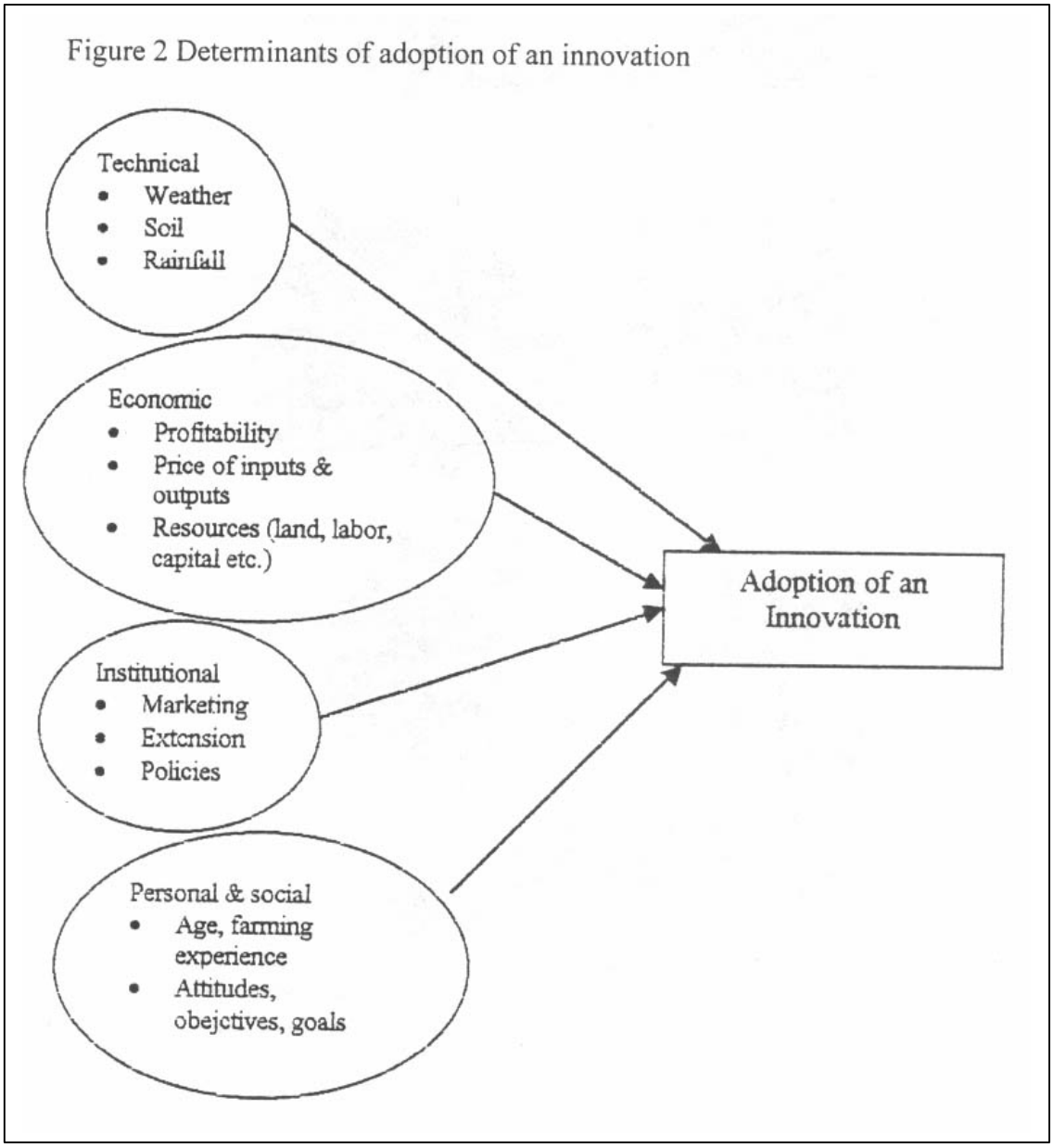
c - Age of coconuts > 20-25 years

Notes a - Light and soil are sub-optimally utilised. Intercropping is feasible.
b - Intermediate stage of palms. Intercropping is not feasible.
c - Light and soil are sub-optimally utilised. Intercropping is feasible.

Source Adapted from Mahindapala and Pinto (1992). 79 p.

Theory of Adoption of an Innovation

As show in Figure 2, a range of factors, which could be broadly categorized as technical, economical institutional, and personal/social, influences the adoption of an innovation.



Among the factors shown in Figure 2, the economic profitability of a technology is one of the key determinants influencing its adoption by farmers. The objective of this paper is to assess the economics of existing CBI systems. More specifically, this study determines the economics of widely practiced five different CBI systems in relation to coconut monocropping.

Hypothesis:

Maintenance of existing mature coconut lands as monocrop is economically worthwhile in relation to intensifying them as CBI systems.

METHODS

Data: A farmer survey was carried out from March to May 1995 to collect the data.

Sample size: The sample comprises 113 coconut-based intercroppers and 37 coconut monocroppers

Survey area: Three main coconut-growing districts in Sri Lanka, namely: Gampaha; Kurunegala; and, Puttalam constitute the survey area.

Sampling Procedure: Although these districts comprise five agro-ecological regions, namely IL^1, WL^2, WL^4 and WM^3, a greater percentage (86%) of Coconut Development Officer (CDO) ranges[1] fall in the IL_1 and WL_3, and hence only the CDO ranges falling in IL_1 and WL_3 were purposively selected for the survey. The land area of the above three districts falling under IL1 agro-ecological region is greater than that of WL_3. Hence, about 60% of sampling units (22 monocroppers and 68 intercroppers) were allocated into WL_3 (Table 1).

Table 1. Allocation of sampling units

	Agro-ecological regions*		
	IL_1	WL_3	Total
Monocroppers	22	15	37
Intercroppers	68	45	113
Total	90	60	150

Sampling units were allocated in each CDO range as follows.

- *Agro-ecological regions are categorized based mainly on 75% expectancy value of annual rainfall. Major soil groups and terrain characteristics are also considered for the categorization.*

IL_1 - : Low-country Intermediate zone 1
WL_2 : Low-country Wet Zone 2
Wl_3 : Low-country Wet Zone 3
WL_4 : Low-country Wet Zone 4
WM_3 : Mid-country Wet Zone 3

Table 2 Distribution of monocroppers and intercroppers in CDO ranges

Agro-ecological region					
WL_2			WL_3		
CDO range	Monocroppers	Intercroppers	CDO range	Monocroppers	Intercroppers
Dummalasuriya	2	8	Nittambuwa	2	7
Kuliyapitiya	2	7	Mirigama	2	7
Welpalla	2	7	Pallewela	3	8
Yackwila	3	8	Minuwangoda	3	8
Dambadeniya	2	7	Urapola	3	8
Weerambugedara	2	7	Weke	2	7
Udubaddawa	3	8			
Dankotuwa	3	8			
Hamangalla	3	8			
Total	22	8		15	45

Analysis

A range of economic indicators is available to measure the relative advantage/disadvantage of a new technology. The importance of each economic indicator for this study and the calculation procedure are outlined below.

Total Gross Margin (TGM)

Annual TGM analysis provides an estimate of the sum of annual net cash flows in the intercrop and monocrop systems. The annual gross output quantities of each product were priced to derive the annual gross income, and deducting the variable costs (see Appendix Tables A1 to A5) derived annual gross margins.

Net Present Value (NPV)

Coconut is a perennial crop and most of the other intercrops observed in the field are semi-perennial crops. The costs and benefits of such crops occur at different times and, therefore, a measure is required to compare the net worth of the monocrop and integrated system over the entire production period. NPVs are employed to meet this objective. The credit scheme of the Perennial Crops Development Project (PECRODEP) which is widely operating through its Participatory Credit Institutes provides loans at 15% interest rate, so a 15% interest rate was used for NPV calculations. A sensitivity analysis is also carried out at 20 and 25%.

Benefit-Cost Ratio (BCR)

This measures the returns in relation to the invested sums. The sum of the discounted benefits was divided by the sum of the discounted costs to derive the BCR.

Returns to Variable Costs

This economic indicator measures the efficiency of the production system with respect to the variable costs involved. Returns to variable cost were computed by dividing the annual gross farm income by the annual farm variable costs.

Returns to Labor

Labor productivity is an important consideration in smallholder agriculture. Returns to labor measured in Rupees per man-day was employed to investigate the relative returns provided by the monocrop and intercropping systems. Non-labor inputs were deducted from the gross farm income in each year, and the result was divided by the total labor use in man-days over the whole season to drive the returns to labor.

The above indicators are separately computed for monocrops as well as intercropping systems.

RESULTS AND DISCUSSION

(A) Economic analysis of existing coconut monoculture systems

The economic analysis of existing coconut monoculture system will be carried out in this section using the above indicators for coconut monoculture system. The testable hypothesis of this analysis is whether the maintenance of existing mature coconut lands, as monocrops is economically worthwhile than introducing coconut-based intercropping (CBI). The inclusion of the establishment

costs of monocrop coconuts would not be helpful in testing this hypothesis, as they are historical (sunk) costs (Famiyeh, 1971). Therefore, only the annual maintenance costs of monocrop coconuts wee included in the calculation.

a) TGM (Total Gross Margin)

Annual input and output data with respect to existing mature coconut monoculture system of the sample farmers were used to derive the total gross margin of coconut monocrop system. Liyanage *et al*. (1988) found that the nut yield of Sri Lanka Tall (SLT) palms increases progressively every year after initial bearing until a maximum[2] is attained at about 16-18 years, and is maintained thereafter depending on the environmental conditions. The average age of the coconut palm in the sample was 41 years and the annual average nut yield was 2946 nuts/acre/year (7277 nuts/ha/year). It could be argued that the representative monocrop stand of the survey sample has already achieved the maximum yield. Therefore, the average yield of 2946 nuts per acre per year would be expected to continue during each year of the entire five years[3] of planning horizon considered for the comparison with the intercropping systems. Table 3 shows the sample average gross margin (Rs/ac/year) of the matured coconut monoculture system.

NPV (Net Present Value) and BCR (Benefit-Cost Ratio)

Constant annual variable costs and gross returns for the entire period of five years were considered to calculate the NPV and BCR of monoculture system (see Appendix Table A6). The calculated NPVs of GMs are Rs. 20,364; Rs. 18,168, and Rs. 16,337 at 15; 20; and 25% discount rates, respectively. The BCR is 2.87.

b) Returns to Labor

This was calculated to be Rs 656 per man day (Appendix Table A6)

c) Returns to Variable Costs

In coconut monoculture systems, this is the same as the BCR (2.87), as it assumes constant annual: a) variable costs and b) gross returns, for the entire five-year period. These results are compared with the corresponding results of CBI systems in the next section to test the relevant hypothesis.

2 The maximum yield is about 3,000 to 4,000 nuts per acre depending on soil, environment and management conditions (Liyanage *et al.* 1988)

3 The reason for considering a five-year period for this comparison is as follows: Monoculture coconuts in the present sample have already achieved the maximum yield and therefore the sample average yield of 2,946 nuts/ac/year will be consistent throughout the rest of the palm life. On the other hand, the input requirements' including labor does not vary much over the years once monocrop coconuts attain the maximum yield. This implies that the TGM of coconut monocrops does not vary over the rest of the palm life given the constant prices used for calculations throughout. Hence, the number of years required for the comparison of monocrop with intercropping systems is dictated by the number of years required by intercrops for an effective comparison. Five years would be sufficient for the comparison because the economic life of semi-perennial intercrops considered is five years.

Table 3 Calculation of annual gross margin (Rs/acre) of coconut monoculture system

OUTPUT	
No. of nuts (per acre/year	2946
Average price (Rs/nut)	3.16
Gross Return (Rs)	9309.36
INPUTS	
Labor use (man days)	
Weeding	5.5
Fertilizer application	3
Nut collection	2.5
Total man days	11
Average wage rate (Rs/man day)	104
Contract labor cost for harvesting (Rs/ac)	582
Sub-total 1 – labor cost (Rs)	1726
Material Cost	
Fertilizer (kg/ac)	12.5
Price (Rs/kg)	8.5
Fertilizer cost (Rs)	1062.5
Sub total 2 materials cost (Rs)	1062.5
Transport Cost	
Fertilizer transport (Rs)	208
Cost for internal field transportation of coconut (Rs)	238
Sub total 3 transport cost (Rs)	446
Variable costs (Rs/ac)	3234.5
Gross Margin (Rs/acre/year	**6074.86**

Note: Ave. age of coconut palms – 41 years Source: Farmer Survey, 1985

(B) Economic Analysis of Existing Coconut-Based Intercropping Systems

The survey has identified an array of different intercropping systems involving various combinations of intercrops, and the relative abundance of each system is shown in Table 4.

Only the first five intercropping systems of the Table 4 namely: coconut + pineapple + banana; coconut + banana; coconut + pineapple; coconut+ betel; and, coconut + betel + banana were used for the economic analysis in view of their widespread practice. Other intercropping systems are relatively less significant. All the five economic indicators, as in the case of monoculture systems, have been calculated for the five different intercropping systems considered. While full details of the calculation procedure are found in Appendix Tables A7, A8, A9, A10 and A11 for the five different intercropping systems, respectively, their summary results are compared here with the results of the monoculture system.

Table 4. Relative abundance of different intercropping systems

No.	Cropping system	Number of farmer practisin	Percentage
1	Coconut + pineapple + banana	30	2.50
2	Coconut + banana	15	13.27
3	Coconut + pineapple	14	12.39
4	Coconut + betel	7	6.19
5	Coconut + betel + banana	6	5.31

6	Coconut + pepper	4	3.54
7	Coconut + pineapple + pepper	4	3.54
8	Coconut + pineapple + banana + ginger	4	3.54
9	Coconut + ginger + banana	3	2.65
10	Coconut + ginger + banana + betel	3	2.65
11	Coconut + banana + pepper + coffee	3	2.65
12	Coconut + pepper + banana	2	1.77
13	Coconut + banana + rambutan	2	1.77
14	Other systems	16	14.15
	Total	113	100.00

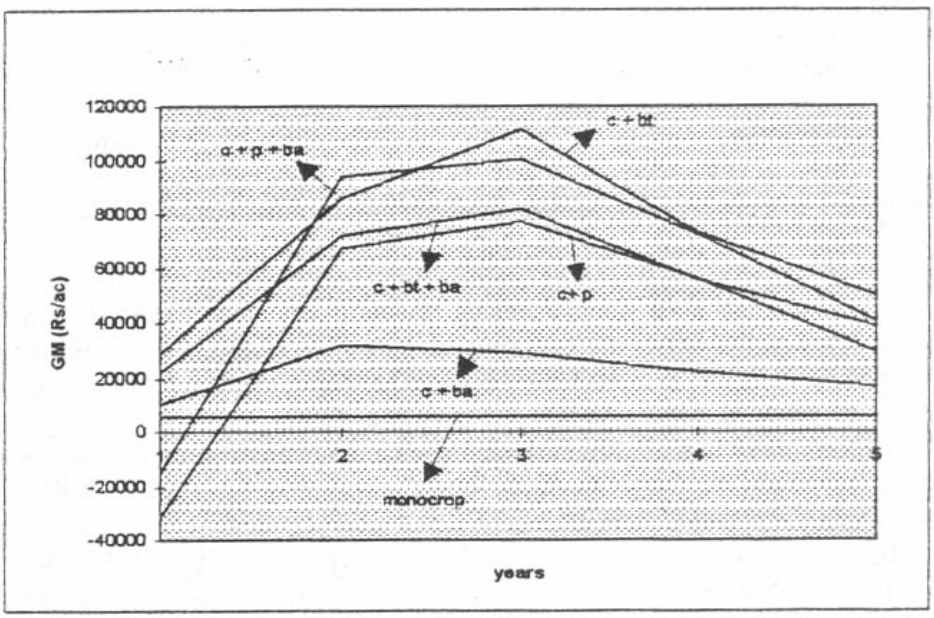
a) TGM

Table 5 and Figure 3 show the annual gross margins of different intercropping systems in comparison with monocrop system.

Table 5. Annual TGM of different cropping systems

Cropping system	Year 1	Year 2	Year 3	Year 4	Year 5
TGM (Rs/ac)					
Monocrop	075	075	6,075	6,075	6,075
Coconut + pineapple + banana	-15,263	94,077	100,420	72,621	40,398
Coconut + banana	10,451	32,040	28,938	2,213	16,933
Coconut + pine apple	-31,061	7,455	76,874	56,241	29,351
Coconut + betel	28,869	85,693	111,045	73,193	49,625
Coconut + betel + banana	22,057	72,058	81,632	55,904	38,969

Figure 3 Annual TGM of different cropping systems



Notes: c - coconuts; p - pineapple; ba - banana; bt - betel.
Source: Table 5.

It is clear that the cropping systems comprising pineapple has negative gross margins in the first year, as pineapple does not generate returns in the first year but incurs high costs of establishment. However, it commences to produce much higher gross margins that the monocrop system from the second year onwards.

Cropping systems consisting of betel and banana generate higher positive gross margins compared to monocrop system in the first year of establishment, as these crops commence to yield in the first year. In summary, the annual gross margin analysis suggests that all the intercropping systems considered are superior to monocrop systems in terms of margins per unit of land. Among them, banana and betel systems are more attractive in terms of providing positive annual gross returns during the entire planning period of five years while pineapple systems have a little longer waiting period. The poorly endowed/resource-poor farmers may be much concerned with sustaining a positive annual cash flow, no matter how low rather than waiting longer to obtain higher cash flows. The better endowed/resourceful farmers may be better able to await for higher returns occurring at later stages. NPV, rather than the TGM analysis, would be a better criterion to investigate the appropriateness of cropping systems for the latter group of farmers.

b) NPV

NPVs generated by all the intercropping systems are markedly higher compared to the coconut monocrop system at all the interest rates addressed (Table 6). The coconut + betel system yielded the highest NPV. The descending order of NPV of other cropping systems is: coconut + pineapple + banana; coconut + betel + banana; coconut + pineapple and coconut + banana.

Table 6. NPV of different cropping systems over five years (Rs/ac)

Cropping system	NPV (Rs)		
	15%	20%	25%
Monocrop	20,364	18,168	16,337
Coconut + pineapple + banana	185,498	161,982	142,397
Coconut + banana	73,417	65,186	58,298
Coconut + pineapple	121,291	104,365	90,336
Coconut + betel	229,434	20,309	18,103
Coconut + betel + banana	178,678	158,282	14,122

Notes: a, b, c are discount rates.
Source: Farmer survey, 1995.

As shown by Table 5, the cropping systems involving pineapple has negative gross margins in the first year whereas the gross margins of monocrop system are positive in all the five years considered[4]. It may therefore be argued that the NPVs of intercropping systems involving pineapple would be lower than those for the coconut monocrops at discount rates beyond the ones addressed in Table 6. Hence, a much higher discount rate (100%) was used to test the sensitivity of NPVs of intercropping systems having pineapple as a component crop. The resultant NPVs were: Rs 5,885; Rs34,241; and, Rs 5,375, respectively for monocrop coconuts, coconut + pineapple + banana system, and coconut + pineapple system. In addition, the NPV of the monocrop system was also compared with the NPVs of the remaining three other intercropping systems at 100% discount rate. Coconut + banana; coconut + betel; and, coconut + betel + banana systems, respectively generated Rs 18,765; Rs55,864; and, Rs43,959 as against the monocrop NVP of Rs5,885.

4 Coconuts also produced negative gross margins in the first few years of establishment. However, this concern requires no consideration here, because the establishment costs can be considered as historical costs as has been discussed.

These results prove beyond reasonable doubt that no matter how high the discount rates, the monocrop coconuts are not competitive with any of the other five intercropping systems in terms of providing higher NPVs. The relatively low returns generated by monocrop coconuts are one of the main problems of maintaining coconuts as a monocrop today. This already held view by researchers and farmers were confirmed by the present finding.

c) BCR

BCRs were calculated for the five different cropping systems as shown in Table 7.

Table 7 BCRs of Different Cropping Systems

Cropping systems	BCR
Monocrop	2.87
Coconut + pineapple + banana	3.24
Coconut + banana	3.07
Coconut + pineapple	2.74
Coconut + betel	1.88
Coconut + betel + banana	2.12

Source: Farmer survey, 1995

The procedure to accept or to reject any project based on BCR criterion, is to accept all those having BCRs greater than unity while rejecting all projects having BCRs lower than unity. Based on this criterion, it is clear that all the cropping systems are financially worthwhile to individual farmers. Perhaps, the most noticeable point is that the coconut monocrop systems exhibit higher BCRs than 3 of the 5 intercropping systems. Coconut monocrop systems utilize less inputs, for instance, less labor and other paid costs for fertilizers etc., but generate benefits more than double in financial terms, indicating that it is a profitable crop. Clearly, the problem of monoculture coconut is not that the return to investment is low, but rather that it generates lower returns per unit of land to growers as evidenced by the previous NPV calculations. Although the coconut + betel system generates the highest NPV/acre compared to other cropping systems (see the results of the NPV calculations in the previous section), the return to investment of this system is the lowest (1.88) compared to the other systems. The reason for this is higher labor inputs required for betel cultivation (labor was valued at market wage rate to compute BCRs). However, betel is an attractive crop for families having high levels of family labor supply. In summary, the BCR analysis reveals that all the cropping systems are financially worthwhile in terms of returns to investment. Of them, the highest BCR was observed in coconut + pineapple + banana system (3.24) while coconut monocrop system also exhibits an attractive BCR (2.87).

d) Returns to family labor

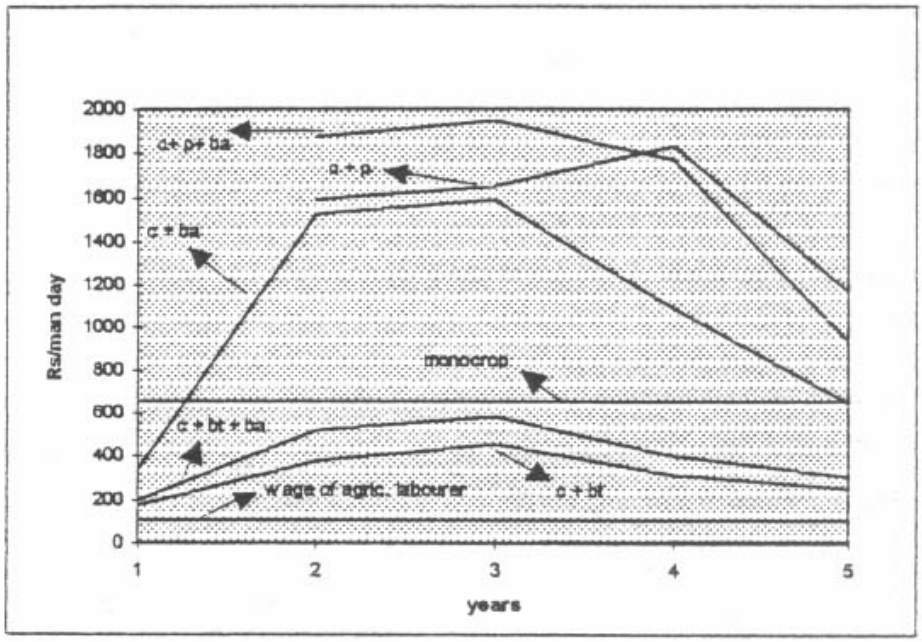
The returns to family labor generated by different cropping systems were compared with the wage rate of an agricultural laborer, and the returns to family labor of monocrop coconuts were compared with that of the other intercropping systems (Table 8).

The monocrop as well as all the intercropping systems generate markedly higher returns to family labor compared to the average wage rate of an agricultural laborer. From the second year onwards, coconut + pineapple + banana, coconut + pineapple and coconut + banana systems generate substantially higher returns to labor than coconut monocrop system. However, intercropping systems involving betel produces lower returns to labor compared to monocrop systems because betel is a highly labor-intensive crop requiring almost daily labor involvement. Figure 4 shows the return to labor of different cropping systems, and compares these with the wage rate of an agricultural laborer.

Table 8. Returns to family labour in different cropping systems

Cropping system	Year 1	Year 2	Year 3	Year 4	Year 5
Rs/man day					
Monocrop	656	656	65	65	56
Coconut + pineapple + banana	(-) ve	1,870	1,955	1,773	941
Coconut + banana	39	1,528	1,588	1,088	650
Coconut + pine apple	(-) ve	158	1,549	1,834	1,171
Coconut + betel	177	378	461	320	254
Coconut + betel + banana	198	519	58	404	309
Wage rate of an agricultural labour	104	104	104	104	104

Figure 4 Return to labour in different cropping systems



Notes: c - coconuts; p - pineapple; ba - banana; bt - betel.
Source: Table 8.

In summary, these results reveal that the return to labor of all the cropping systems analyzed is higher than the wage rate of agricultural laborer. This indicator is particularly high in pineapple and banana systems, although the labor requirements of these crops are also higher. The higher returns to labor of these systems, while utilizing high levels of labor, are mainly due to their higher gross margins. Higher returns to labor of monocrop systems are mainly due to the inherent low labor utilization. The low returns to labor in cropping systems involving betel is not due to higher returns per acre (NPV calculations indicated that betel systems are the highest NPV earners), but due to their much higher labor requirement.

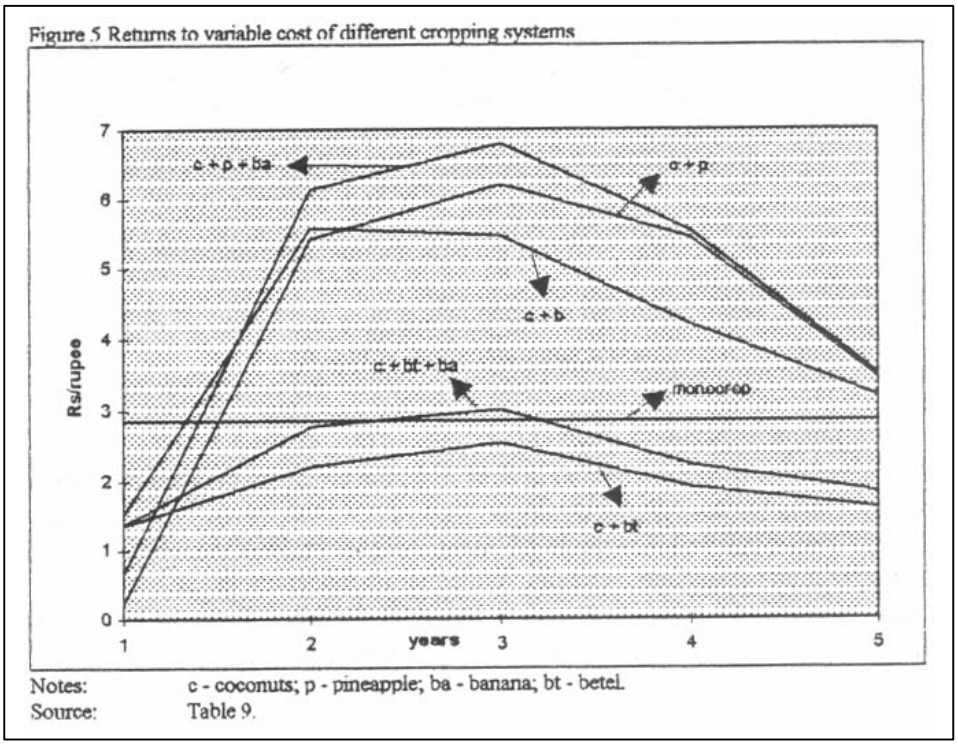
e) Returns to variable costs

Table 9 and Figure 5 show the returns to variable costs for different cropping systems in different years.

Table 9. Returns to variable costs in different cropping systems

Cropping system	Year 1	Year 2	Year 3	Year 4	Year 5
Returns to variable costs (Rs/rupee invested)					
Monocrop	2.87	2.87	2.87	2.87	2.87
Coconut + pineapple + banana	0.67	6.13	6.80	5.54	3.50
Coconut + banana	1.50	5.59	5.47	4.20	3.21
Coconut + pine apple	0.23	5.42	6.21	5.45	3.46
Coconut + betel	1.35	2.19	2.54	1.89	1.61
Coconut + betel + banana	1.37	2.76	3.01	2.21	1.83

Source: Farmer survey, 1985



Notes: c - coconuts; p - pineapple; ba - banana; bt - betel.
Source: Table 9.

In the first year, all the intercropping systems show a relatively low return to variable costs compared to the monocrop system, which is obviously due to the high cash outlays associated with the intercrop establishment. But from the second year onwards, the coconut + pineapple + banana; coconut + pineapple and coconut + banana systems begin to generate markedly higher returns to variable costs compared to the monocrop system. The interesting feature is that the intercropping systems involving betel always exhibit a tendency to yield low returns to variable costs compared to the monocrop system, except that the coconut + betel + banana system generate a marginally higher returns to variable costs only in the third year. These results suggest that the generation of gross return relative to the utilization of variable costs is higher in pineapple and banana intercropping systems compared to the coconut monocrop system while it is less in betel intercropping systems. The results also indicate that coconut monoculture has an ability to generate higher gross returns relative to the variable costs.

Thus far, the analysis has been confined only to the most prevalent intercropping system found in the survey, and involving semi-perennial intercrops such as pineapple, banana and betel. However, there exists a range of other perennial intercropping systems including crops such as pepper, coffee, cocoa, etc. Although they were not found widely practiced during the survey, they

deserve comparing with monocrops because their lower abundance was mainly due to the persistence of low market prices for them in recent years [5]. However, farmers expect an increased price for them in years to come.

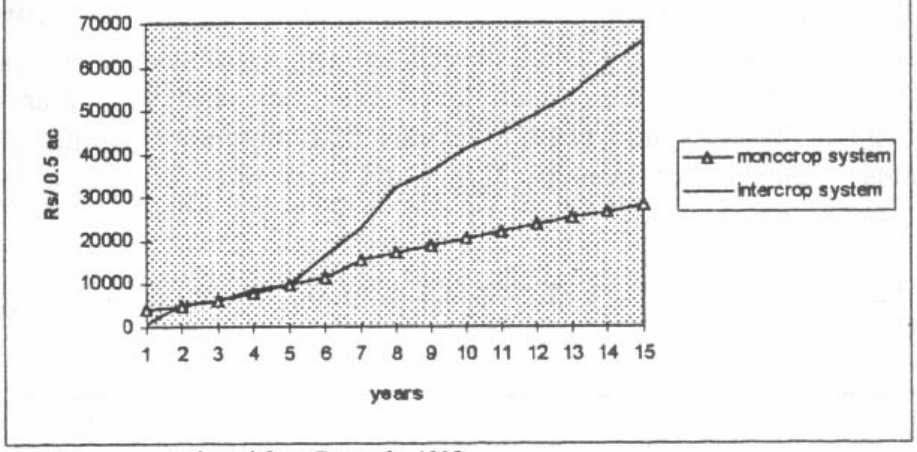
The main difficulty in comparing perennial intercropping systems with monocrop coconuts arises with regard to the excessive data requirements as perennial intercrops take over ten years to attain the full potential production. For instance, coffee and pepper respectively take 11 and 10 years to reach full production. However, the farmers were unable to provide sufficient accurately remembered data with regard to these intercrops, and this precluded a rigorous comparison with monocrops coconuts. The author has, however, compared a monocrop system with a perennial intercropping system [6] using six years of actual data, collected from a crop model established in a farmer's field, supplemented with nine years of budgeted data (full details are reported elsewhere, Fernando (1995)). The findings of that comparison may be useful to infer how monocrop coconuts compare with a perennial intercropping system over fifteen years (see Table 10 and Figure 6). The GM of the intercropping system in the first year is less than that of the monocrop system because of the higher costs involved in planting intercrops. It is almost the same as the monocrop system from year 2 to 5, after which it increases progressively due to the benefits accrued by pepper and coffee as well as the incremental nut yield resulting from the complementary effect of intercropping.

Table 10. Comparison of annual total gross margins (Rs/0.5 ac) of a monocrop system with a perennial intercropping system

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Monocrop system	4,019	4,747	5,949	7,910	9,660	11,350
Intercropping system	976	5,448	6,013	8,702	9,782	1,096

Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
15,326	17,002	18,652	20,272	21,860	23,496	25,091	26,640	23,137
22,983	32,072	35,960	40,945	44,616	49,049	53,530	60,422	65,741

Figure 6 Annual total gross margin of monocrop and intercropping systems



Source: Adapted from Fernando, 1995.

5 A sudden drop in price of these perennial intercrops took place about a decade ago, resulting in a reduction of their widespread growing.

6 This consists of pepper and coffee (ginger was grown only in one year).

Fernando (1995) has also examined the NPV of the monocrop and intercropping systems, at different discount rates, for two different periods, namely a six-year period of actual data, and a fifteen-year period of actual plus budgeted data (Tables 11 and 12, respectively).

Table 11 Comparison of NPV (Rs/0.5 ac) of monocrop and intercropping systems over six years

Interest rate (%)	Monoculture system	Intercropping system
5	37,609	39,795
10	32,839	34,112
25	23,350	22,919
30	21,230	20,446
40	17,952	16,646

It is clear that the NPV of the perennial intercropping system in the short run (6 years) is higher compared to the monocrop system at low interest rates of 5% and 10%, but the opposite is the case at higher interest rates.

The NPVs of both monocrop and intercropping systems break even at the 20% discount rate, above which the NPV of monocrops is higher compared to intercropping system, and below which the NPV of intercropping system is higher compared to monocrop system (Fernando, 1995). However, the comparison over the long run (15 years), as demonstrated by Fernando (1995), reveals that the intercropping system generates higher NPVs even at higher discount rates compared to the monocrop system.

Table 12 Comparison of NPV (Rs/0.5 ac) of monoculture and intercropping systems over 15 years

Interest rate %	Monoculture system	Intercropping system
10	107298	183946
25	45575	66094
30	36881	50523
40	26213	32210

Source: Fernando, 1995

These findings confirm that intercropping systems involving perennial intercrops considered generate higher incomes compared to monocrops. However, the returns to labor and variable costs of perennial intercropping system analyzed are less compared to the monocrop system (Fernando, 1995).

Comparison of the results obtained for different economic indicators with respect to coconut monoculture and coconut-based intercropping systems do not provide sufficient evidence to accept the hypothesis that the coconut monoculture systems are economically advantageous than CBI systems. Rather, it provides strong evidence that the intercropping systems are economically advantageous in relation to monocrop system. However, some of the indicators, namely; BCR and returns to variable costs, are reasonably attractive for monocrop coconuts, though they are less than for some intercropping systems.

SUMMARY

Coconuts are cultivated predominantly as a monocrop in almost all coconut growing countries, including Sri Lanka. Monocrop coconut use bio-physical resources such as soil, sunlight, etc. sub-optimally. Coconut-based intercropping (CBI) is a strategy to intensify the use of above resources while raising farmers' income. Despite this agronomic promise, the adoption of CBI systems by farmers is as low as 25% of the agronomically potential area of 100,000 ha notwithstanding the government efforts over 20 years. Economic profitability, albeit not the sole criterion, greatly influences the adoption of new technologies by farmers.

A study was conducted to assess the economics of widely practised five different CBI systems vis-à-vis coconut monocropping. The CBI systems considered were: coconut + pineapple + banana; coconut + banana; coconut + pineapple; coconut + betel; and, coconut + betel + banana. Data were collected by a field survey of 113 coconut-based intercroppers and 37 coconut monocroppers, conducted during March to May 1995 in three main coconut growing districts, namely: Kurunegala; Gampaha; and, Puttalam. Five economic indicators, namely: Total Gross Margin (TGM); Net Present Value (NPV); Benefit-Cost Ratio (BCR); returns to labor; and, returns to capital were employed to test the hypothesis that the coconut monocrooping is economically worthwhile in relation to CBI. The results revealed the following.

- TGM and NPV were markedly higher in all the five intercropping systems analyzed compared to monocrops. However, the CBI systems involving pineapple showed a negative TGM in the first crop year because pineapple does not generate returns to cover the costs in the first year. However, the BCRs were less in three of the five intecropping systems than monocrops.
- Returns to labor of all intercropping systems were greater than the agricultural wage rate.
- Two of the five intercropping systems had lower returns to labor and to variable costs as compared with monocrops, while three of the five intercropping systems had lower BCRs than monocropping.

CONCLUSIONS

The results obtained for five different economic indicators with regard to coconut monocropping and coconut-based intercropping (CBI) provide strong evidence to prove that CBI systems are economically advantageous vis-à-vis coconut monocropping. Although not the sole criterion, the profitability of an agricultural innovation is a key consideration for its adoption by small farmers. This study has concluded that CBI systems generate higher incomes per unit of land than coconut monocrops. Hence, we argue that the low rate of adoption of CBI is not a problem of low profitability and thus refute the conventionally held view that the low adoption of CBI is tied to low economic profitability of CBI systems. The problem may rest on some other factors, which include: demand for the management of the crop and its inputs, and a skilled knowledge compared to monocropping. These management demands include procuring of: disease-free planting materials; fertilizer; flowering hormones; fiber dust from fiber mills, all with critical timing; hired labor management; etc. The skilled knowledge includes the practical skill of planting different intercrops at different spacing, timely application of flowering hormones for pineapple, harvesting at the right time, disease precaution measures etc. (e.g. soft rot disease in ginger, panama disease in banana, and wilt in pineapple, etc). The risk perception about the innovation being unsuccessful and the risk associated with yield and price outcomes of intercrops appear to be the other factors constraining the adoption of CBI by farmers. Equally, the study thus concludes with emphasizing the need for exploring the influence of above less-frequently addressed factors on adoption of coconut-based intercropping in Sri Lanka.

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APPENDIX

Table A1 Gross margin of ginger cultivation under coconuts (Rs/ac)

OUTPUT	
Ginger (cwt/ac)	47
Average price (Rs/cwt)	1,325
Income from ginger (Rs/ac)	62,805
GROSS RETURN (Rs/ac)	62,805
INPUTS	
Labor use (md/ac)	
Land clearing	5
Land preparation	11
Dipping in chemicals	4
Planting	8
Fertilizer application	6
Mulching	8
Weeding	23
Harvesting	22
Application of insecticide	5
Processing	30
Total labor use (md/ac)	119
Wage rate (Rs/md)	104
Labor cost (Rs/ac)	*
Materials	
Seed singer (cwt.ac)	9
Price of seed ginger	1,450
Seed ginger cost (Rs/ac)	13,746
Fiber dust-number of 4WT/ac	45
Price per 4WT (Rs)	95
Cost of fiber dust (Rs/ac)	4,237
Inorganic fertilizer (kg/ac)	450
Average price (Rs/kg)	10
Cost of inorganic fertilizer (Rs/ac)	4,343
Cost of insecticide & fungicides (Rs/ac)	768
Total material cost (Rs/ac)	23,094
Transport	
Fiber dust – number of 4WT	45
Ave. cost for transport one 4WT (Rs)	139
Fiber dust transport cost (Rs/ac)	6,199
Planting materials transport	193
Fertilizer 1 –transport cost (Rs/ac)	256
Fertilizer 2 – transport cost (Rs/ac)	100
Total transport cost (Rs/ac)	6,748
Machinery	
Land preparation (Rs/ac)	1,570
Variable costs total (Rs/ac)	31,412
GROSS MARGIN (Rs/ac)	31,393

Notes: Errors in sums are due to rounding
1 Sterling pound is approximately Rs 95 in July 1997
1 cwt = 112 pounds (50 kg) md – man-days
* labor was not valued, 4WT – four-wheel tractor
Source: Farmer survey, 1995

Table A2 Gross margin of banana cultivation under coconuts (Rs/ac)*

	Years				
OUTPUT	**1**	**2**	**3**	**4**	**5**
Bunches/ac	122	180	177	151	146
Average price (Rs/bunch	154	143	130	107	73
Income from bunches (Rs/ac)	18,788	25,740	23,010	16,157	10,658
Suckers	240	300	234	271	350
Average price (Rs/sucker)	13.22	13.22	13.22	13.22	13.22
Income from suckers (Rs/ac)	3,173	3,966	3,093	3,583	4,627
Gross return (Rs)	21,961	29,706	26,103	19,740	15,285
INPUTS					
Labour (md/ac)					
Land cleaning	6				
Land preparation	5				
Cutting pits	7				
Dipping in chemicals	1				
Planting	3				
Fertilizer application	4	4	4	4	4
Fiber dust mulching	4				
Weeding	6	6	5	5	6.5
Removal of suckers	2	4	4	5.5	11
Application of insecticide	1				
Removal of old banana logs		3	1	1	
Harvesting	2	2	2	3.5	6
Total md/ac	41	19	16	19	27.5
Wage rate (Rs/md)	104	104	104	104	104
Labour cost **					
Materials					
Number of suckers	158				
Average price (Rs/sucker)	13.22				
Cost of suckers (Rs/ac	2089				
Fiber dust (number of 4WTs)	35.5				
Price per 4WT (Rs)	69				
Cost of fiber dust (Rs/ac)	2,444				
Inorganic fertilizer (Rs/ac)	211	221	224	239	223
Average price (Rs.kg)	8.5	8.5	8.5	8.5	8.5
Cost inorganic fertilizer (Rs/ac)	1,793.5	1,878.5	1,904	2,031.5	1,895.5
Cost insecticides and fungicides (Rs/ac)	274	215			
Total material cost (Rs/ac)	6,600	2,093.5	1,904	2,031	1,895.5
Transports cost					
Number of 4WTs of fiber dust	35.5				
Average cost for transport/one load of 4WTs	152				
Fiber dust transport cost (Rs/ac)	5,396				
Planting materials transport cost (Rs/ac)	238				
Fertilizer transport cost (Rs/ac)	121.75	121.75	121.75	121.75	121.75
Total transport cost (Rs/ac)	5,755.75	121.75	121.75	121.75	121.75
Machinery					
Land preparation (Rs/ac)	1,415				
Total machinery cost (Rs/ac)	1,415				
Total variable cost (Rs/ac)	13,771	2,215	2,026	2,153	2,017
Gross Margin (Rs/ac)	8,190	27491	24078	17586	13268

Notes: Error in sums are due to rounding

* - (158 plants per ac), ** - labour was not valued, md-man-days, 4WT- 4wheel tractors, 1 Sterling pound is approximately Rs 95, in July 1997.

Source: Farming survey, 1995

Table A3 Gross margin of pineapple cultivation under coconuts (Rs/ ac)*

	Year				
OUTPUT	1	2	3	4	5
number of fruits	-	6302	9148	8929	5375
average price (Rs/ fruit)	-	11	7.9	5.9	4.55
income form fruits (Rs/ac)	-	69322	72269	52681	24456
number of suckers	-	1770	4367	3000	3258
average price (Rs/sucker)	-	2.3	2.3	2.3	2.3
income from suckers (Rs/ac)	-	4071	10044	6900	7493
Gross return (Rs/ac)	-	73393	82313	59581	31950
INPUTS					
Labour (md)					
land clearing	6.5				
land preparation	13				
dipping in chemicals	2				
Planting	12				
fertilizer application	7	5	5	5	4.5
Weeding	10	12.5	12	9	7
fibre dust mulching	17				
earthing up of fibre dust	6.5				
application of insecticide	2	2	2.3	1.33	1
application of hormones	2	2.5	3	4	2.5
fruit protection		8	10		
Harvesting		4	5.25	6	5
removal of suckers		3	4	4	4
removal of leaves		5	5		
Total labour use (md)	78	42	47	29.33	24
wage rate (Rs/md)	104	104	104	104	104
Total labour cost **					
Materials					
number of suckers	3545				
average price (Rs/sucker)	2.3				
cost of suckers (Rs/ac)	8153.5				
fibre dust - number of 4WTs	50				
price (Rs/4WT)	71				
cost of fibre dust (Rs/ac)	3550				
fertilizer (kg/ac)	737	747	626	595	569
average price of fertilizer (Rs/kg)	8.5	8.5	8.5	8.5	8.5
cost of fertilizer (Rs/ac)	6264.5	6349.5	5321	5057.5	4836.5
cost of insecticide and fungicides (Rs/ac)	399	494	506	457	464
cost of weedicide (Rs/ac)	901	717	809	809	809
cost of flowering hormone (Rs)	177	220	203	211	204
Total material cost (Rs/ac)	19445	7780.5	6839	6534.5	6313.5
Transport cost					
number of 4WTs of fibre dusts	50				
cost for transport one load of 4WT	149				
fibre dust transport cost (Rs/ac)	7450				
planting material transport cost (Rs/ac)	341				
fertilizer transport cost (Rs)	315	315.25	315.25	315.25	315.25
Total transport cost (Rs/ac)	8106	315.25	315.25	315.25	315.25
Machinery					
land preparation (Rs/ac)	1881				
Total machinery cost (Rs/ac)	1881				
Total variable cost (Rs/ac)	29432	8095.75	7154	6850	6628.75
Gross Margin (Rs/ac)	-29432	65297	75159	52731	25321

Notes: Errors in sums are due to rounding.
* - (3545 plants per ac), ** - labour was not valued
md - mandays, 4WT - 4-wheel tractors.
1 Sterling pound is approximately Rs 95, in July 1997.

Source: Farmer survey, 1995.

Table A4 Gross margin of betel cultivation under coconuts (Rs/ 1000 sticks)

	Year				
OUTPUT	1	2	3	4	5
number of leaves	132984	217460	511052	610000	610000
average price (Rs/leave)	0.38	0.34	0.17	0.12	0.1
income form leaves (Rs/1000 sticks)	50534	73936	86879	73200	61000
Gross return (Rs/1000 sticks)	50534	73936	86879	73200	61000
INPUT					
Labour (md)					
land clearing	3				
ploughing (by mammoty)	6.5				
pegging	2.5				
bed preparation	6				
Planting	3				
Slashing	0.5				
planting sticks	3				
organic fertilizer application	7.5	6	7	6	6
inorganic fertilizer application	13.5	14	13	13	13
training young vines	3				
preparation of wooden supports	7				
installing wooden supports	8				
Weeding	8	9	8	2.5	2.5
making earthen drains	12.5				
Watering	32	31	27	19	19
harvesting and staking leaves	75	80	89	120	120
cleaning drains		5	4	4	
planting sticks		6.25	2		
Total labour use (md/1000 stocks)	191	151.25	150	164.5	160.5
wage rate (Rs/md)	104	104	104	104	104
Total labour cost **					
Materials					
number of sticks	1000				
average price (Rs/stick)	2				
cost of sticks (Rs/1000 sticks)	2000				
cost of organic fertilizer (Rs/1000 sticks)	3517	2992	2703	2563	2563
inorganic fertilizer (kg)	422	442	522	860	860
price (Rs/kg)	12	12	12	12	12
Inorganic fertilizer cost (Rs/1000 sticks)	5064	5304	6264	10320	10320
number of shoots	2000				
price (Rs/shoot)	0.62				
cost of shoots (Rs)	1240				
cost of binding wire (Rs)	386				
cost of material for wooden supports (Rs)			192		
cost of arecanut trees (Rs)	328				
number of sticks		100	114		
price (Rs/stick)		2.75	3		
cost of sticks (Rs)		275	342		
cost of twines (Rs)		50	25		
Total material cost (Rs)	12535	8621	9334	12883	12883
Transport					
transport cost of sticks (Rs)	236				
transport cost of leaves to the fair (Rs/trip)	100	100	100	100	100
number of trips per year	14	50	50	50	50
transport t cost of leaves (Rs/year)	1400	5000	5000	5000	5000
fertilizer transport cost (Rs)	293.5	293.5	293.5	293.5	293.5
transport cost of arecanut trees (Rs)	400				
transport cost of sticks (Rs)		100	100		
Total transport cost (Rs)	2329.5	5393.5	5393.5	5293.5	5293.5
Machinery					
pump hiring cost for watering (Rs/day/1000 sticks)	17.5	17.5	17.5	17.5	17.5
number of days watering practiced per year	240	240	240	240	240
cost for pump hire (Rs)	4200	4200	4200	4200	4200
Total machinery cost (Rs)	4200	4200	4200	4200	4200
Variable cost (Rs/1000 sticks)	19064.5	18214.5	18927.5	22376.5	22376.5
Gross Margin (Rs/1000 sticks)	31469	55722	67951	50823.5	38623.5

Notes: Errors in sums are due to rounding.
* - (3545 plants per ac), ** - labour was not valued
md - mandays, 4WT - 4-wheel tractors.
1 Sterling pound is approximately Rs 95, in July 1997.

Source: Farmer survey, 1995.

Table A5 Gross margin of coconut monoculture systems (Rs/ac)

OUTPUT	
No of nuts per year	2,946
Average price (Rs/nut)	3.16
Cross Return (Rs)	9,309
INPUTS	
Labour use (in md)	
Weeding	6
Fertilizer application	3
nut collection	3
Total and	11
Average wage rate(Rs/day)	0
Harvesting (Rs contract labour)	582
Sub Total 1 -labour cost (Rs)	582
Materials cost (Rs)	
Fertilizer (kg/ac)	125
price (Rs/kg)	9
Fertilizer cost (Rs)	1,063
Sub Total 2 - mareials cost (Rs)	1,063
Transport cost	
Fertilizer transport (Rs)	208
internal field transportation of coconut (Rs)	238
Sub Total 3 - transport cost (Rs)	446
Variable costs (Rs/ac)	2,091
CM (R.--,/ac)	7,219

Notes: Errors in sums are due to rounding.

Average age of coconut palms = 41 years.

Average number of bearing palms per acre = 64 md -mandays.

1 Sterling pound is approximately Rs 95, in July 1997. Source: Farmer survey; 1995.

Table A6

i)	Computation of NPV (Rs/ac) of the coconut monoculture systems					
		Year 1	Year 2	Year 3	Year 4	Year 5
Gross margin (Ra/ac)		6074.86	6074.86	6074.86	6074.86	6074.86
	NPV of five years of GM (at 15 % interest rate) = Rs 20363. 8 per acre					
	NPV of five years of GM (at 20 % interest rate) = R9 18168.0 per acre					
	NPV of five years of GM (at 25 % interest rate) = Rs 16337.0 per acre					
ii)	Computation of B/C ratio of the coconut monoculture systems					
	B/C ratio = 9309.36/3234.5 = 2.87814					
iii)	Computation of returns to labour					
	- cost * of non-labour inputs (RR/ac)					2,090.5
	- gross return less cost of non-labour inputs (Rs/ac) non-labour inputs (Re/ac)					7,218.86
	- total labour use (md/ac/year)					11
	Returns to labour (Rs/md)					656.26
iv)	Computation of returns to variable costs					
	Total farm variable cost (RS/ac)					3,234.5
	Gross return (Rs/ac)					9,309.36
	Returns to variable cost					2.87814
	(Rs/Rupee)					

Notes: * - contract labour cost was also included, and - tuna day, 1 Sterling pound was approximately Rs 95, in July 1997.

Source: Farmer survey, 1995.

Table A7 Economics of intercropping system 1 (coconut + pineapple + banana)*

	Years				
	1	2	3	4	5
Gross Return (Rs/ac)					
coconut	9309	9309	9309	9309	9309
pineapple	0	73393	82313	59581	31950
banana	21961	29706	26103	19740	15285
Total gross return (Rs/ac)	31270	112408	117725	88630	56544
INPUTS					
Labour (md/ac)					
coconut collection	3.5	3.5	3.5	3.5	3.5
contract cost for picking coconuts (Rs/ac)	1920	1920	1920	1920	1920
pineapple	44.5	29.5	31.25	20	17
banana	28	11	11	13	21
common activities	24.75	9.25	8.5	7	6.75
Total (md/ac)	100.75	53.25	54.25	43.5	48.25
wage rate (Rs/md)	104	104	104	104	104
Total labour cost including contract labour cost (Rs/ac)	12398	7458	7562	6444	6938
Materials cost					
coconuts (Rs/ac)	-	-	-	-	-
pineapple (Rs/ac)	15895	7780	6839	6534	6313
banana (Rs/ac)	4156	2093	1904	2031	1895
common activities (Rs/ac)	3442				
Total material cost (Rs/ac)	23493	9873	8743	8565	8208
Transport cost					
coconuts (Rs/ac)	500	500	500	500	500
pineapple (Rs/ac)	341				
banana (Rs/ac)	238				
common activities (Rs/ac)	7915	500	500	500	500
Total transport cost	8994	1000	1000	1000	1000
Machinery					
Total machinery cost for common activities (Rs/ac)	1648				
Total variable cost (Rs/ac)	46533	18331	17305	16009	16146
Gross Margin (Rs/ac)	-15263	94077	100420	72621	40398

Notes: Errors in sums are due to rounding.
* This system is 1 ac and it comprises 64, 3545, and 158 numbers of coconut palms, pineapple and banana plants respectively.
md - man days, 1 Sterling pound was approximately Rs 95, in July 1997.

Source: Farmer survey, 1995.

NPV of five year GMs at 15% discount rate = Rs 185498/ac
Discounted benefits (at 15% discount rate) = Rs 268381/ac
Discounted costs (at 15% discount rate) = Rs 82833/ac
Benefit-cost ratio (at 15% discount rate) = 3.24

Calculation of return to labour

	year 1	year 2	year 3	year 4	year 5
cost of non-labour inputs - Rs/ac, (contract labour also included)	36055	12793	11663	11485	11128
Gross return less cost of non-labour inputs (Rs/ac)	-4785	99615	106062	77145	45416
Total labour use (md/ac)	100.75	53.25	54.25	43.5	48.25
Returns to labour (Rs/md)	-47.49	1871	1955	1773	941

Calculation of returns to variable costs (Rs/rupee)

	year 1	year 2	year 3	year 4	year 5
Total farm variable cost (Rs/ac)	46533	18331	17305	16009	16146
Gross return (Rs/ac)	31270	112408	117725	88630	56544
Returns to variable costs (Rs/rupee)	0.67	6.13	6.80	5.54	3.50

Table A8 Economics of intercropping system 2 (coconut + banana)*

	Years				
	1	2	3	4	5
Gross Return (Rs/ac)					
Coconut	9309	9309	9309	9309	9309
Banana	21961	29706	26103	19740	15285
Total gross return (Rs/ac)	31270	39015	35412	29049	24594
INPUTS					
Labour (md/ac)					
coconut collection	3.5	3.5	3.5	3.5	3.5
contract cost for picking coconuts (Rs/ac)	1920	1920	1920	1920	1920
Banana	41	19	16	19	27.5
Total (md/ac)	44.5	22.5	19.5	22.5	31
wage rate (Rs/md)	104	104	104	104	104
Total labour cost including contract labour cost (Rs/ac)	6548	4260	3948	4260	5144
Materials cost					
coconuts (Rs/ac)	-	-	-	-	-
banana (Rs/ac)	6600	2093	1904	2031	1895
Total material cost (Rs/ac)	6600	2093	1904	2031	1895
Transport cost					
coconuts (Rs/ac)	500	500	500	500	500
banana (Rs/ac)	5756	122	122	122	122
Total transport cost	6256	622	622	622	622
Machinery					
Total machinery cost for banana(Rs/ac)	1415	-	-	-	-
Total variable cost (Rs/ac)	20819	6975	6474	6913	7661
Gross Margin (Rs/ac)	10451	32040	28938	22136	16933

Notes: Errors in sums are due to rounding.
* This system is 1 ac and it comprises 64 and 158 numbers of coconut palms and banana plants respectively.
md - man days, 1 Sterling pound was approximately Rs 95, in July 1997.
Source: Farmer survey, 1995.

NPV of 5 year GM s at 15% discount rate = Rs 73417/ac
Discounted benefits (at 15% discount rate) = Rs 108813/ac
Discounted costs (at 15% discount rate) = Rs 35396/ac
Benefit-cost ratio (at 15% discount rate) = 3.07

Calculation of return to labour

	year 1	year 2	year 3	year 4	year 5
cost of non-labour inputs - Rs/ac, (contract labour also included)	16191	4635	4446	4573	4437
Gross return less cost of non-labour inputs (Rs/ac)	15079	34380	30966	24476	20157
Total labour use (md/ac)	44.5	22.5	19.5	22.5	31
Returns to labour (Rs/md)	338.85	1528	1588	1087	650

Calculation of returns to variable costs (Rs/rupee)

	year 1	year 2	year 3	year 4	year 5
Total farm variable cost (Rs/ac)	20819	6975	6474	6913	7661
Gross return (Rs/ac)	31270	39015	35412	29049	24594
Returns to variable costs (Rs/rupee)	1.50	5.59	5.47	4.20	3.21

Table A9 Economics of intercropping system 3 (coconut + pineapple)*

	Years				
	1	2	3	4	5
Gross Return (Rs/ac)					
Coconut	9309	9309	9309	9309	9309
Pineapple	0	73393	82313	59581	31950
Total gross return (Rs/ac)	9309	82702	91622	68890	41259
INPUTS					
Labour (md/ac)					
coconut collection	3.5	3.5	3.5	3.5	3.5
contract cost for picking coconuts	1920	1920	1920	1920	1920
Pineapple	78	42	46.25	29	24
Total (md/ac)	81.5	45.5	49.75	32.5	27.5
wage rate (Rs/md)	104	104	104	104	104
Total labour cost including contract labour cost (Rs/ac)	10396	6652	7094	5300	4780
Materials cost					
coconuts (Rs/ac)	-	-	-	-	-
pineapple (Rs/ac)	19337	7780	6839	6534	6313
Total material cost (Rs/ac)	19337	7780	6839	6534	6313
Transport cost					
coconuts (Rs/ac)	500	500	500	500	500
pineapple (Rs/ac)	8256	315	315	315	315
Total transport cost	8756	815	815	815	815
Machinery					
Total machinery cost for pineapple (Rs/ac)	1881				
Total variable cost (Rs/ac)	40370	15247	14748	12649	11908
Gross Margin (Rs/ac)	-31061	67455	76874	56241	29351

Notes: Errors in sums are due to rounding.
* This system is 1 ac and it comprises 64 and 3545 numbers of coconut palms and pineapple plants respectively.
md - man days, 1 Sterling pound was approximately Rs 95, in July 1997.

Source: Farmer survey, 1995.

NPV of five year GM s at 15% discount rate	= Rs 121291/ac
Discounted benefits (at 15% discount rate)	= Rs 190773/ac
Discounted costs (at 15% discount rate)	= Rs 69483/ac
Benefit-cost ratio (at 15% discount rate)	= 2.74

Calculation of return to labour

	year 1	year 2	year 3	year 4	year 5
cost of non-labour inputs - Rs/ac, (contract labour also included)	31894	10515	9574	9269	9048
Gross return less cost of non-labour inputs (Rs/ac)	-22585	72187	82048	59621	32211
Total labour use (md/ac)	81.5	45.5	49.75	32.5	27.5
Returns to labour (Rs/md)	-277	1586	1649	1834	1171

Calculation of returns to variable costs (Rs/rupee)

	year 1	year 2	year 3	year 4	year 5
Total farm variable cost (Rs/ac)	40370	15247	14748	12649	11908
Gross return (Rs/ac)	9309	82702	91622	68890	41259
Returns to variable costs (Rs/rupee)	0.23	5.42	6.21	5.45	3.46

Table A10 Economics of intercropping system 4 (coconut + betel)*

	Years				
	1	2	3	4	5
Gross Return (Rs/ac)					
Coconut	9309	9309	9309	9309	9309
betel	101068	147872	173758	146400	122000
Total gross return (Rs/ac)	110377	157181	183067	155709	131309
INPUTS					
Labour (md/ac)					
coconut collection	11	11	11	11	11
contract cost for picking coconuts	1000	1000	1000	1000	1000
betel (md)	382	302	300	328	320
Total (md/ac)	393	313	311	339	331
wage rate (Rs/md)	104	104	104	104	104
Total labour cost including contract labour cost (Rs/ac)	41872	33552	33344	36256	35424
Materials cost					
coconuts (Rs/ac)	1062	1062	1062	1062	1062
betel (Rs/2000 plants)	25070	17242	17984	25766	25766
Total material cost (Rs/ac)	26132	18304	19046	26828	26828
Transport cost					
coconuts (Rs/ac)	446	446	446	446	446
betel (Rs)	4658	10786	10786	10586	10586
Total transport cost	5104	11232	11232	11032	11032
Machinery					
Total machinery cost for betel (Rs/ac)	8400	8400	8400	8400	8400
Total variable cost (Rs/ac)	81508	71488	72022	82516	81684
Gross Margin (Rs/ac)	28869	85693	111045	73193	49625

Notes: Errors in sums are due to rounding.
* This system is 1 ac and it comprises 64 and 2000 numbers of coconut palms and betel plants respectively (modal number of betel plants observed in the survey per holding was 2000 plants).
md - man days, 1 Sterling pound was approximately Rs 95, in July 1997.

Source: Farmer survey, 1995.

NPV of 5 year GM s at 15% discount rate	= Rs 229434/ac
Discounted benefits (at 15% discount rate)	= Rs 489512/ac
Discounted costs (at 15% discount rate)	= Rs 260078/ac
Benefit-cost ratio (at 15% discount rate)	= 1.88

Calculation of return to labour

	year 1	year 2	year 3	year 4	year 5
cost of non-labour inputs - Rs/ac, (contract labour also included)	40636	38936	39678	47260	47260
Gross return less cost of non-labour inputs (Rs/ac)	69741	118245	143389	108449	84049
Total labour use (md/ac)	393	313	311	339	331
Returns to labour (Rs/md)	177	378	461	320	254

Calculation of returns to variable costs (Rs/rupee)

	year 1	year 2	year 3	year 4	year 5
Total farm variable cost (Rs/ac)	81508	71488	72022	82516	81684
Gross return (Rs/ac)	110377	157181	183067	155709	131309
Returns to variable costs (Rs/rupee)	1.35	2.20	2.54	1.89	1.61

Table A11 Economics of intercropping system 5 (coconut + betel + banana)*

	Years				
	1	2	3	4	5
Gross Return (Rs/ac)					
Coconut	9309	9309	9309	9309	9309
Pineapple	30534	73936	86879	73200	61000
Banana	21961	29706	26103	19740	15285
Total gross return (Rs/ac)	81804	112951	122291	102249	85594
INPUTS					
Labour (md/ac)					
coconut collection	3.5	3.5	3.5	3.5	3.5
contract cost for picking coconuts	1920	1920	1920	1920	1920
Betel	191	151	150	164	160
Banana	41	19	16	19	27
Total (md/ac)	235.5	173.5	169.5	186.5	190.5
wage rate (Rs/md)	104	104	104	104	104
Total labour cost including contract labour cost (Rs/ac)	26412	19964	19548	21316	21732
Materials cost					
coconuts (Rs/ac)	-	-	-	-	-
Betel	12535	8621	8992	12883	12883
banana (Rs/ac)	6600	2093	1904	2031	1895
Total material cost (Rs/ac)	19135	10714	10896	14914	14778
Transport cost					
coconuts (Rs/ac)	500	500	500	500	500
Betel	2329	5393	5393	5293	5293
banana (Rs/ac)	5756	122	122	122	122
Total transport cost (Rs/ac)	8585	6015	6015	5915	5915
Machinery cost (Rs/ac)					
Betel	4200	4200	4200	4200	4200
banana	1415				
Total machinery cost (Rs/ac)	5615	4200	4200	4200	4200
Total variable cost (Rs/ac)	59747	40893	40659	46345	46625
Gross Margin (Rs/ac)	22057	72058	81632	55904	38969

Notes: Errors in sums are due to rounding.
* This system is 1 ac and it comprises 64, 1000, and 158 number of coconut palms, betel and banana plants respectively.
md - man days, 1 Sterling pound was approximately Rs 95, in July 1997.
Source: Farmer survey, 1995.

NPV of five year CM s (at 15% discount rate)	= Rs 178678/ac
Discounted benefits (at 15% discount rate)	= Rs 337966/ac
Discounted costs (at 15% discount rate)	= Rs 159288/ac
Benefit-cost ratio (at 15% discount rate) (at 15% discount rate)	= 2.12

Calculation of return to labour

	year 1	year 2	year 3	year 4	year 5
cost of non-labour inputs - Rs/ac, (contract labour also included)	35255	22849	23031	26949	26813
Gross return less cost of non-labour inputs (Rs/ac)	46549	90102	99260	75300	58781
Total labour use (md/ac)	235.5	173.5	169.5	186.5	190.5
Returns to labour (Rs/md)	198	519	586	404	309

Calculation of returns to variable costs (Rs/rupee)

	year 1	year 2	year 3	year 4	year 5
Total farm variable cost (Rs/ac)	59747	40893	40659	46345	46625
Gross return (Rs/ac)	81804	112951	122291	102249	85594
Returns to variable costs (Rs/rupee)	1.37	2.76	3.01	2.21	1.83