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Kandyan Gardens of Sri Lanka

V.J. JACOB[1] and W.S. ALLES[2]
[1]*UNDP/FAO Research Project on Minor Export Crops, Matale, Sri Lanka*
Present address: FAO Cashewnut Research Project, Regional Research Station, P.O. Box 9120064, Mongu, Zambia
[2]*Department of Minor Export Crops, Research Station, Matale, Sri Lanka*

1. Introduction

Kandyan Gardens (KG) or Kandyan Forest Gardens (KFG) of Sri Lanka represent a traditional system of perennial cropping which has been in practice for several centuries. It is essentially a system of mixed cropping with a variety of economically valuable groups of tree crops such as spices, fruits, medicinal plants and timber species. However, these systems are usually in small homestead holdings and are practised in a few districts, especially Kandy, Matale and Kurunegalle in the 'mid-country' region of Sri Lanka. In the district of Kandy, this is the most predominant cropping system and hence the name 'Kandyan Gardens' or 'Kandyan Forest Gardens'. The mixed forest-gardening system offers a highly diversified and economically viable form of land use. Similar systems are also being practised in several other densely populated parts of humid lowlands, for example, in India, Thailand, Malaysia, Indonesia and Papua New Guinea in South-east Asia [4, 5, 8, 9]. However, the Kandyan forest garden system is different from these other homegarden systems mostly in terms of the variety of plants grown. Moreover the farmers who practise the Forest garden systems in Sri Lanka enjoy a 'relatively better' level of living by virtue of returns from both the economic cash crops and the subsistence products. Presumably, with improved management, the system has the potential for increased production and better returns. This paper examines the situation with respect to the Kandyan garden system and endeavours to identify the directions of research for the improvement of the system. The data presented in the paper are based on a survey of 30 farms of the locality [7] and on results of mixed cropping experiments conducted by the minor export crops research project [2, 4, 5, 6].

2. General description of the area

The details of climate, rainfall, temperature, topography, soils, etc. of Sri Lanka are described in a recent paper on intercropping under coconuts in Sri Lanka.

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as a part of the 'Agroforestry System Description Series' [3]. A considerable proportion of KFG in the three districts (Kandy, Matale and Kurunagalle) is located in the intermediate rainfall zone (mean annual rainfall of 1875–2000 mm) and in mid-elevations (450–1050 m) with hilly terrains. The KFG system is practised on a variety of soil types with predominance in strongly to weakly lateritic soils, and in most cases on sloping land.

As already described in the earlier-mentioned paper [3], the major agroforestry systems of Sri Lanka other than KG (KFG) are '*Chena*' (a form of shifting cultivation), some forms of taungya, intercropping under coconut, and growing tea and coffee under the shade of trees with wind-breaks or shelter belts.

The area of land under various crops and other land use systems in the three districts where the Kandyan garden system is practised is given in Table 1. It is worth noting that these three districts have only 4.1% of land under forest compared to the national average of 24.9%. This is because of the relatively large areas under export crops such as tea, rubber, cacao, cardamom and black pepper; these three districts account for 35.4, 8.0, 94.3, 80.7, 66.6 percents respectively of the total areas under these crops in Sri Lanka.

3. Structure of the Kandyan Gardens

Kandyan home gardens are small homestead holdings, the size of the 30 farms surveyed varying from 0.4 to 2.0 ha with an average of 1 ha per holding.

3.1 Composition

This system is primarily based on perennnial and semi-perennial trees and shrubs. The survey of thirty farms [7] revealed that as many as 20 crops or

Table 1. Land use in the three districts of Sri Lanka where the Kandyan garden system is practised

	Area in the district (ha)			Total area (ha)	% of Sri Lanka's total
	Kandy	Matale	Kurunegalle		
Total land	215,770	199,530	477,590	892,890	13.6
Large inland waters	20	–	320	340	0.35
Forest	23,000	33,200	10,500	66,500	4.1
Rice	37,967	18,728	109,704	166,399	19.0
Tea	78,249	7,990	376	86,615	35.4
Rubber	5,881	7,036	5,804	18,721	8.4
Cacao	3,015	4,439	522	7,976	94.3
Cinnamon	17	68	12	97	0.4
Cardamom	1,949	2,294	34	4,277	80.7
Cintronella	–	90	–	90	3.6
Black pepper	2,652	3,021	388	6,061	66.8

components were grown in the system, indicating a very high degree of crop combination and diversification (Table 2). The most important crops in the system, by frequency of occurrence are: trees, such as area (*Areca catechu*), jack fruit (*Artocarpus heterophyllus*), and coconut (*Cocos nucifera*); bushes of plantain and coffee; and black pepper vines (*Piper nigrum*). Among minor export cash crops, cacao is grown in about 25% of the farms. A general picture of a Kandy garden system is given as Figure 1. The highest number of crops grown on a farm was 18 (on a 2 ha farm) and the lowest 4 (on a 1.2 ha farm). Eighty percent of the farms grew 8–15 crops. There was no relationship between the farm size and crop diversity.

3.2 Arrangement of components

The crops generally do not seem to be grown according to any specific pattern or planting arrangement but they appear to be in a random though intimately mixed pattern (Figure 2). However, it is not logical to conclude that a system

Table 2. Crops grown in the Kandyan Gardens

Name of crop	Number of farms in which grown (out of the 30 farms surveyed)
Area *Area catechu*	28
Jack fruit *Artocarpus heterophyllus*	26
Coffee *Coffea* spp.	26
Black pepper *Piper nigrum*	26
Coconut *Cocos nucifera*	25
Plantain *Musa* spp.	25
Tea *Camelia sinensis*	23
Cloves *Syzygium aromaticum*	20
Nutmeg *Myristica fragrans*	15
Citrus *Citrus* spp.	15
Papaya *Carica papaya*	15
Vegetables	14
Avocado *Persea americana*	11
Kitul *Caryota urens*	10
Flowers	9
Mangosteen *Garcinia mangostana*	7
Cacao *Theobroma cacao*	7
Breadfuit *Artocarpus altilis*	5
Yams *Dioscorea* spp.	5
Durian *Durio zibethinus*	5
Rice *Oryza sativa*	3
Fodder grasses	2
Mango *Mangifera indica*	2
Cardamom *Elettaria cardamomum*	2
Rubber *Hevea brasiliensis*	2
Pineapple *Ananas comosus*	2
Rambutan *Nephelium lappaceum*	1
Passion fruit *Passiflora edulis*	1
Ginger *Zingiber officinale*	

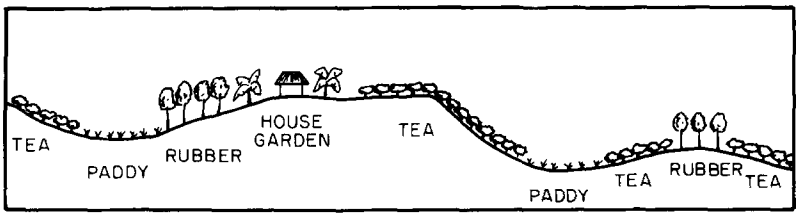


Fig. 1. Schematic presentation of the general land-use pattern in the areas of Kandyan garden system.

that has evolved over centuries and is still providing *good sustenance* (someone has called it 'affluent subsistence') to the farmers, could be casual about location, spacing and site conditions of perennial cash crops. It can be surmised that those who practise the system know, in a practical way, what and where to plant and how to manage the plants. The small holders of tea, rubber and coconut, for example, plant their tree crops according to a pattern indicating their awareness and perception of the specific site conditions and requirements of the crops.

It is difficult to generalize the spacing between individual crops and the number of each species grown per unit area.

In very simple terms, the total number of all trees/bushes per ha varies from 65 to as high as 1700 or even more. It is difficult to devise an acceptable index of cropping intensity for a situation where crops are grown at several tiers of canopy configuration. Crops such as yams, vegetables, and tea are at low heights; coffee, cacao, citrus, and plantains at medium heights; and all these under the canopy of trees such as coconut, areca, mango, etc., in a recognisable

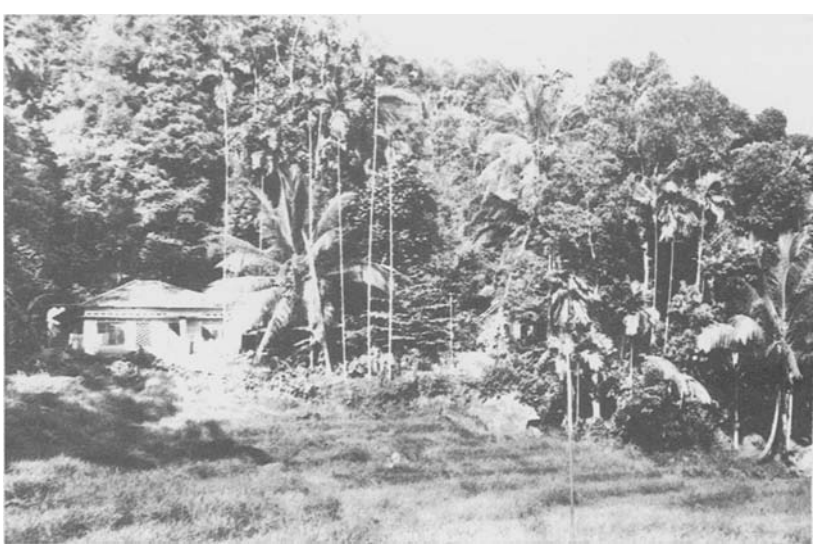


Fig. 2. Photograph of a Kandyan garden (photo: V.J. Jacob)

but not a definite order. It is observed that most of the high density plantings occur on those farms where coffee and areca are the dominant components (Table 3). There is a tendency in high density farms to fill up any space where coffee is not grown with more than the usual number of areca palms, which, because of their slender, tall stems and light crowns, can be squeezed into such gaps.

An analysis of plant density, especially of areca palms, in relation to farm size suggested that the density of plantation was related to farm size — the bigger the farm, the lesser the density: mean densities (of areca palms) on 0.4, 0.8, 1.2 ha farms being 315,237, 102 and 56 trees per 0.4 ha (1 acre) respectively. However, as mentioned earlier, holding size had no relation to species diversity.

3.3 Interaction of components

Obviously there could be interactions among the plants, and between plants and their environment, in such an intimate system of plant association; but no data is available on this aspect. What distinguishes the Kandyan garden system from other land use systems is the intensive utilization by plants of both the above-ground and the below-ground resources both vertically and laterally. Nair [10, 11] has discussed some of the aspects of plant interactions in such intensive mixtures. It is also possible that being a mixture of many crop species, the risk of crop pests and diseases associated with monocropping systems is minimal. However, all these are in the realm of rationalization as there is no scientific data available from these systems to either prove or disprove these conjectures.

4. System functioning

Resource input and utilization

All the farms surveyed were owner-cultivated. On an average, each farm has 2.54 full time adult male labour equivalent (AME). 1 AME = 1 adult male = 1.4 adult female = 2.5 children. The distribution of utilization of family labour in the Kandyan garden system (Table 4) indicated that picking and harvesting or various crops used the most family labour (37.9%) followed

Table 3. Crop density in relation to coffee and areca in Kandyan gardens

Item	Average for 7 high density farms	Average for 7 low density farms
Area (ha)	0.75	1.54
Total trees (no.) per ha	1,040	113
Coffee bushes (no.) per ha	528	23
Areca palms per ha	170	28

Table 4. Use of family labour for different farm operations in Kandyan gardens

Farm operations	% of family labour used
Planting	3.0
Cultivation	8.9
Weeding	19.3
Harvesting	37.9
Drying	15.0
Marketing	11.9

by weeding (19.3%) and drying/processing (19.0%). These data indicate that one of the primary aspects of management is collecting and gathering produce from the tree crops either for sale or consumption by the family. The usually important operations of subsistence agriculture namely planting/sowing and digging/cultivating are relatively unimportant and account for only 3.0 and 8.9% of family labour respectively. Many categories of hired labour such as part time, full time, day labour with or without meals, contract work, etc. are identifiable, and are used for various farm operations. It is interesting that although family labour is usually available on the farms and most of it not meaningfully employed otherwise, there is quite a heavy dependence on hired labour (from outside) for farm operations. An average of 62% of the total labour requirements on the farm is met by hired labour, the larger the farm the more the use of such hired labour. One reason for this phenomenon is that harvesting of crops such as tea, clove, black pepper, etc., is considered a skilled work, which family labour is not usually capable of doing, and such operations constitute the major component of labour requirement for many crops in the system (Table 5).

Cash requirement for operating costs is generally low: an average of Sri Lankan Rupees 710 per hectare (1 US $ being approx. SL Rs. 25 in late 1984). The cost of hired labour (87.8%), fertilizers (5.9%), transportation (3.4%), hand tools (1.4%) and chemicals (0.7%) are the items of this expenditure. About 90% of the total cash expenses for farm operations were on a relatively small number of crops such as tea, coconut, black pepper, areca, cloves, coffee, vegetables and rice.

Level of debt incurred on the farms surveyed was low (an average of only SL Rs. 229 per farm at the time of survey).

4.2 Production

The yield of crops in a forest garden can be quantified in terms of yield of units of individual crops in the gardens, and the value of yields per unit area can better be described in terms of monetary returns/value of the yield. Table 6 summarises the average yield levels of 25 crops covered in the survey of 30 Kandyan gardens described in this paper.

Table 5. Production of crops in the Kandyan gardens

Crops*	Unit		Yield/Unit		Quantity sold	Quantity consumed on farm	Distribution (%)	
	Plant/area	Produce	Green	Dry			Sold	Used
Black pepper	vine	kg	4.20	1.10	1.18	0.04	96	04
Kitul	palm	bottles of vine	16.92	–	16.29	0.63	96	04
Arecanut	tree	no. of nuts	312	–	307	5	98	02
Plantain	tree	bunches	0.94	–	0.97	0.15	84	16
Jack	tree	no. of fruits	12.43	–	0.83	11.60	07	93
Mangosteen	tree	no. of fruits	174	–	150	24	86	14
Citrus	tree	no. of fruits	34	–	21	13	62	38
Papaya	tree	no. of fruits	11	–	2	9	18	82
Nutmeg	tree	kg	–	0.74	0.74	–	100	0
Cloves	tree	kg	2.69	0.88	0.88	–	100	0
Rubber	tree	kg	–	3.52	3.52	–	100	0
Cacao	tree	kg	–	0.32	0.32	–	100	1
Coffee	tree	kg	2.09	0.45	0.02	0.03	93	07
Durian	tree	kg	105	–	79	26	75	25
Vegetables	ha	kg	985	–	863	120	88	12
Rice	ha	bushels of 27.20 kg each (60 lbs)	–	107	–	107	–	100
Flowers (anthuriums)	plant	no. of flowers	6.56	–	6.35	0.21	95	05
Mango	tree	no. fruits	806	–	762	44	95	05
Rambutan	tree	no. fruits	1700	–	1500	200	88	12
Pineapple	plant	no. of fruits	0.80	–	0.60	0.20	75	25
Yams	ha	kg	1004	–	892	112	89	11
Breadfruit	tree	no. fruits	384	–	318	66	83	17
Tea	ha	kg	863	–	863	–	100	–
Coconut	palm	no. of nuts	101	–	76	25	72	25
Avocado	tree	no. of fruits	186	–	164	22	88	12

* See Table 1 for details.

The data in Table 6 indicate that the level of total production and income per farm is fairly high and steady throughout the year except in the month of February. However, the pattern of production from an individual farm will depend on the composition of the crop mix on that farm. To evaluate the seasonal distribution of income within the year on individual farms, a 'Time Concentration Index' is used. This index refers to the square root of the sum of squares of deviation of the monthly income from the average monthly income. If 100 units represent the total yearly income of a farm (i.e., an average of 8.3 units of income per month), and if all of it is received in a monocrop with only single harvest per year, the time concentration index is:

$$\sqrt{(8.3 - 100)^2 + (8.3 - 0)^2 + (8.3 - 0)^2 + + +} = \sqrt{9167} = 95.8.$$

In a similar way, if the total income is evenly distributed throughout the year, the index is 0. It was observed that of the 30 farms surveyed, 11 farms had indices less than 50, and the other 19 had indices more than 50. The high index was identified to be associated with clove. Of the 11 farms which had low index, only few grew cloves; on the other hand all the 19 farms which had indices higher than 50, grew cloves. When cloves were excluded from calculation, the mean value of index was only 32 and as many as 25 farms had indices less than 50 indicating that the labour requirement was spread out evenly during the year.

Cloves accounted for 42.2% of all cash farm income, followed by pepper (14.9%), tea (12.3%), coconut (11.9%), banana (5.2%), coffee (3.6%), nutmeg (1.8%), and areca (1.7%). These eight crops contributed 93.6% of the cash income. Six of these crops are low volume and high value crops and some of them enter the export market. The low cash-income products — milk, vegetables, kitul, anthurium, durian, other fruits, economic and food crops — are all subsistence products, which are sold only when there is a surplus. Mean cash

Table 6. Yield and value of crops harvested from forest gardens during different months of the year

Month	Average number of crops harvested each month on a farm	Monthly value of production per farm (mean of 30 forest gardens) *Rs. (Sri Lanka)	%
Jan.	5.4	151	3.8
Feb.	6.3	2382	59.6
Mar.	4.4	230	5.8
Apr.	4.0	149	3.7
May	3.3	135	3.4
Jun.	3.4	123	3.1
Jul.	3.4	143	3.5
Aug.	3.8	134	3.4
Sep.	4.0	164	4.1
Oct.	4.0	130	3.3
Nov.	4.2	127	3.1
Dec.	5.2	130	3.2

* 1 US $ = approx. SL Rs 25 (1984).

farm income was Rs. 4085/- per ha and Rs. 1120/- per adult male equivalent (AME) of farm family members.

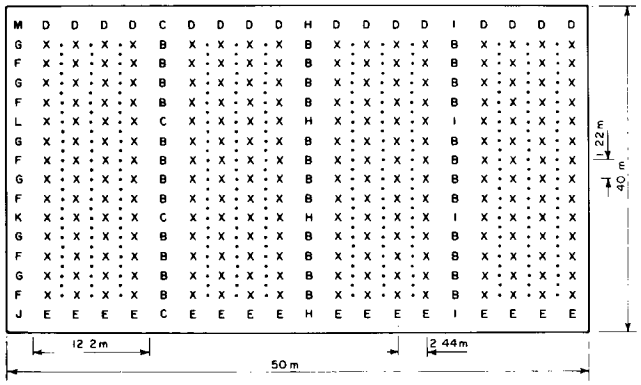
One characteristic of the Kandyan garden is the amount and diversity of sustenance it provides. All the farms surveyed had significant non-cash food income, the mean of such income per farm being Rs. 271/- per ha annually. Coconut accounted for 42.4% of the non-cash food income produced and consumed, the others being jack fruit seed (16.9%), banana (13.3%), black pepper (8.8%), coffee (4.4%), durian (3.8%), and vegetables (2.9%).

A look at the hill sides where the Kandyan garden system is practised will convince any one that it provides an excellent cover to the land at various levels. However, these protective and service aspects have not been quantified or studied in any detail.

5. Constraints and potentials

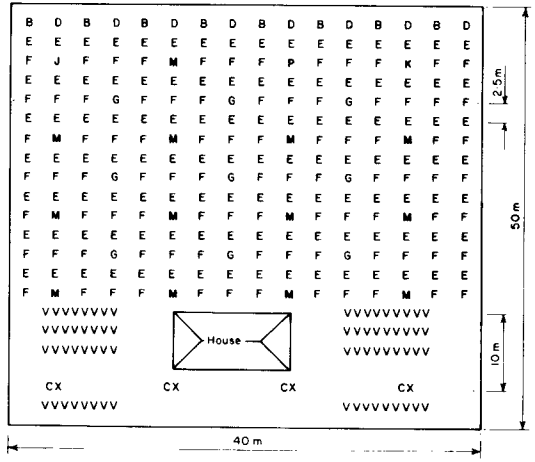
The Kandyan or forest garden system is one of the best examples of integrated land-use system in the densely populated humid tropics. This system provides food, fuel, fodder, fruit, beverages, spices, small timber, regular cash inflow and work to the farmer on the one hand, and conserves the production on a sustainable basis on the other. In spite of this, a major constraint to the improvement of the system is that it has not been understood scientifically.

The scope for improvement of the system is illustrated by the very promising results from a research programme supported by a UNDP/FAO project at the Research Station of the Department of Minor Export Crops in Matale, near Kandy [1,2]. Experiments on crop combination were initiated in 1978 in marginal and eroded tea lands. Fourteen different plant species of varying canopy architecture and growth habits were included in carefully designed planting patterns, a model of which is given in Fig. 3. The income generation potential of this model is shown in Table 7. Figure 4 shows the photograph of a section of such a high intensity combination, five years after planting the crops.
Banana and papaya in the crop mix started yielding in the second year after planting and coffee and black pepper in the third year. It has been estimated that the return from this crop combination after all crops have attained full production would be the equivalent of US $ 2880 per hectare annually at the 1983 rate of exchange and value of crops (Table 7).
This is just one example of what could be accomplished from the Kandyan home gardens. At present, the system is operating at a very low level of efficiency. With more research back-up and extension efforts, the efficiency of the system can be improved considerably. The system can also be extended to other areas in Sri Lanka. For example the Land Utilization Committee of Sri Lanka, estimated that as early as 1967, about 18,000 ha of tea small holdings of less than 4 ha each were severely eroded and non-remunerative. Judging from the results of the UNDP/FAO project, the high-intensity crop model of the Kandyan garden pattern offers great scope for improving the productivity of these lands. Sri



A. Model for high intensity cropping

Code crop	Spacing	No./ha
Large canopy		
C Coconut	12.2 × 12.2 m	36
H Nutmeg	12.2 × 12.2 m	12
I Clove	12.2 × 12.2 m	12
J Jack fruit	12.2 × 12.2 m	3
K Breadfruit	12.2 × 12.2 m	3
L Avocado	12.2 × 12.2 m	3
M Mango	12.2 × 12.2 m	3
Medium canopy		
X Pepper	2.44 × 2.44 m	1296
B Coffee (Robusta)	2.44 × 2.44 m	220
D Arecanut	2.44 × 2.44 m	24
E Banana	2.44 × 2.44 m	24
F Papaw	2.44 × 2.44 m	22
G Lime	2 44 × 2.44 m	22
Small canopy		
Dwarf Coffee (San Ramon)	1.22 × 1.22 m	1926



B. Model for homestead farming by paddy (rice) farmers

Code crop	Spacing	No./0.2 ha
Large canopy		
M Mango	10 × 10 m	13
C Coconut	10 × 10 m	4
J Jack fruit	10 × 10 m	1
K Breadfruit	10 × 10 m	1
P Guava	10 × 10 m	1
Medium canopy		
B Coffee (Robusta)	2.5 × 2.5 m	8
D Arecanut	2.5 × 2.5 m	8
E Banana	2.5 × 2.5 m	112
F Papaw	2.5 × 2.5 m	87
G Lime	2.5 × 2.5 m	9
X Pepper	on coconut	4
Small canopy		
V Vegetables Tubers, etc.		

Fig. 3. Planting patterns for multilayer perennial crop combinations in the small holdings of Sri Lanka.

Fig. 4. Photograph of a combination of black pepper + *Gliricidia sepium*, as part of a high intensity crop combination, five years after establishment (photo: P.K.R. Nair, ICRAF)

Lanka's environmental conditions are such that a vast number of high value export crops can be grown. There is a good possibility for stepping up the production of these crops in the marginal lands of degraded small holdings of tea and rubber through appropriate crop diversification efforts. The system can also be extrapolated with appropriate modifications to other areas with similar environmental conditions outside Sri Lanka.

Table 7. Estimated annual return from a one-hectare mixed cropping model at Delpitiya planted – November 1978

Crops/Yield years after	Yield (kg/plant) or No. of fruits/plant							No. of plants	Total yield	Unit* price	Total* value
	1	2	3	4	5	6	7				
Pepper (kg)	Nil	0.2	0.3	0.5	0.8	1.0	1.0	1296	1296	25.00	32,400
Coffee – R (kg)	Nil	Nil	0.2	0.4	0.6	0.75	0.75	220	165	30.00	4,950
Coffee – S (kg)	Nil	0.1	0.2	0.3	0.4	0.5	0.5	1914	957	30.00	28,710
Clove (kg)	Nil	Nil	Nil	0.1	0.2	0.5	1.5	12	18	100.00	1,800
Nutmeg (no.)	Nil	Nil	Nil	Nil	25	100	500	12	6000	0.2	1,200
Coconut (no.)	Nil	Nil	Nil	5	15	25	50	36	1810	1.5	2,700
Mango (no.)	Nil	Nil	10	30	40	50	50	3	150	0.5	75
Jack fruit (no.)	Nil	Nil	Nil	5	10	15	15	3	45	2	90
Breadfruit (no.)	Nil	Nil	Nil	5	15	30	50	3	150	1	150
Avocado (no.)	Nil	Nil	Nil	10	30	50	50	3	3	0.2	30
Arecanut (no.)	Nil	Nil	Nil	10	50	100	100	24	2400	0.2	480
Banana (no. of bunches)	Nil	1	1	1	1	1	1	24	24	10	240
Lime (no.)	Nil	Nil	Nil	10	20	50	100	44	4400	20	880
12 crops								3594			73,705

R = Robusta Coffee
S = San Ramon Coffee
* = Value in Sri Lanka rupees at 1983 price; 1 US $ = SL Rs. 25 (approx.)

6. Research needs

The Research Station at Matale has conducted some studies for the improvement of the Kandyan home garden system. However, these efforts need to be greatly stepped up in view of the scope for improvement. Some of the agronomic aspects that need to be examined in detail before the suggested new models [1] are recommended to farmers include:

— selection of appropriate species and assessment of their compatibility with each other;
— arrangements and spacing of various component crops according to the level of input and management;
— use of improved, high yielding, fast growing cultivars and varieties;
— response of various individual components and the system as a whole to management constraints;
— input-output relations at various levels;
— long term effects and sustainability attributes of various combinations.

Acknowledgements

Being a system description, this paper has drawn upon various sources, notably the report of McConnel and Dharamapala [7]. The authors also are grateful to Dr. K.G. Tejwani for the asistance rendered in preparing the manuscript and to Dr. P.K.R. Nair, ICRAF, for the encouragement in publishing it.

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