

## CROP COMBINATION AND YIELD PATTERN IN COFFEE MIX CROPPED WITH CARDAMOM

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### ABSTRACT

The compatibility and yield pattern of robusta coffee and arabica coffee both as mono and mixed crop with cardamom was studied in Kodagu, Karnataka. Robusta coffee mix cropped with cardamom recorded 1988 kg/ha as against 2626 kg/ha as a mono crop. Cardamom as a mixed crop with robusta coffee in double hedge recorded the highest yield of 1400.5 kg dry capsule/ha during the fourth year of its planting and the average of seven crop seasons was 672.30 kg/ha. On an average the gross and net returns were more by 5.17 and 4.06 times in mixed cropping respectively compared to monocropping. The Net Present Worth (NPW) and Benefit Cost Ratio (BCR) were higher in mixed cropping by 232.78 and 74.18% respectively, which indicated the profitability of mixed cropping of robusta coffee with cardamom over mono cropping of robusta coffee.

Dry yield per plant and per hectare of arabica coffee as a mono crop was significantly higher compared to mixed cropping with cardamom. Dry cardamom capsule yield was highest during the third year of its mixed cropping with arabica coffee. There was reduction in the yield of arabica coffee per hectare when mix cropped with cardamom as the population of arabica coffee retained was exactly half by removing an alternate row (1134 plants/ha). The encouraging yield of cardamom obtained in the mixed cropping system, greatly compensated the total productivity and returns per unit area as revealed by economic analysis. Net return was higher by 303.1 per cent in the mixed crop stand as compared to mono cropping

### INTRODUCTION

Coffee is a popular beverage all over the world. In India, traditionally Robusta and Arabica coffee are the two important commercial species of coffee cultivated in the hills and valleys of western ghats. Coffee is cultivated in three lakh hectares with an average production of 200,000 M.T. per annum. Among traditional coffee growing states of India, Karnataka enjoys the pride position in terms of area and production, the contribution from this state to the National goal is around 70% comprising of around 20,000 tonnes of arabica and 70,000 tonnes of robusta.

holdings of below two hectares. Productivity and economic returns from these small holdings are meagre. If at all returns from these holdings is to be improved, there is a need to grow high value and low gestation compatible crops like cardamom to improve and sustain high income from available land with a flow of income at different periods of the year (Awataramani, 1977; Bavappa, 1977; Korikanthimath and Peter, 1992).

In recent years, there has been a considerable interest in mixed/multistoreyed cropping in export oriented plantation crops because of the imperative need to increase production and productivity consequent upon the increased pressure on land. Thus, it is quite necessary to introduce more than

Majority (86.03%) of the coffee plantations in India are classified as small

one crop species in cropping sequences to increase cropping intensity in space and time in plantation crops (Nelliath *et al.* 1974, Rethinam and Venugopal, 1994). The earlier studies carried out in this regard with crops like banana, pepper and orange have revealed that the increased total income from these component crops compensated the loss due to the low yield of coffee in certain years due to the seasonal variation and unprecedented drought (Ramaiah, 1990).

Although cultivation of coffee with associate crops like cardamom was seen in the ravines, no systematic studies were conducted to find out the crop compatibility. Hence, to systematise the cultivation and management of mixed cropping of cardamom with coffee, two separate field experiments on mixed cropping viz., robusta coffee + cardamom and arabica coffee + cardamom were undertaken at Chettalli in Coorg district of Karnataka which contributes 33% of total production of coffee in India and 50% in Karnataka, to assess the yield and economics of these crop combinations.

## MATERIALS AND METHODS

The field experiments were started in predominantly coffee growing area of Northern parts of Kodagu district, Karnataka at M/S Chettoli Estate, Chettalli. The average rainfall during the experimental period was 1401 mm spread over from May to December, with conventional blossom showers for coffee in March/April. The soils are classified as "Kandic paleustalf" and is sandy loam in texture. The soils are moderately acidic (pH 5.58), rich in available nitrogen (organic carbon 2.55%), low in phosphorus (4.9 mg/100 g) and medium in potash (17.8 mg/100 g). The water holding capacity of the soil is 14 per cent.

### Robusta coffee + cardamom

The experiment conducted for 9 crop seasons (1985-86 to 1993-94) constituted two

treatments, with 10 replications viz., mono cropping of robusta coffee ( $M_1$ ) and mixed cropping of robusta coffee with cardamom ( $M_2$ ). The gross and net plot size were 500 and 400 m<sup>2</sup> respectively.

The varieties planted were Perdinia in case of robusta coffee and C1.37 (Malabar type) in case of cardamom. The monocropping of robusta coffee was spaced at 2.7 m x 2.7m (1372 plants/ha).

Alternate rows of robusta coffee planted during the year 1947 at a spacing of 2.7 m x 2.7 m was removed during May, 1985. Thus, the coffee got the spacing of 5.4 m x 2.7 m in mixed cropping ( $M_2$ ) treatment with a population of 686 plants/ha. The inter row space of 5.4 m was used for planting cardamom during June, 1985 at a spacing of 1.8 m x 1.2 m (2315 plants/ha) as a paired row in the middle of robusta coffee rows. The experiment was laid out in Factorial RBD.

### Arabica coffee + cardamom

The field experiment was started during the year 1992, to study the compatibility and productivity of arabica coffee with cardamom. The experiment was conducted in Factorial RBD with 10 replications for three years (1992-93 to 1994-95). There were two treatments (cropping systems) viz. Mono cropping of arabica coffee ( $M_1$ ) and mixed cropping of arabica coffee with cardamom ( $M_2$ ), with a gross plot size of 500 m<sup>2</sup> and net plot size of 400 m<sup>2</sup>. The crop varieties used were selection No. 795 of arabica coffee and clone 37 (Malabar) in cardamom. Alternate rows of arabica coffee (planted in 1982) at a spacing of 2.1 m x 2.1 m were removed in 1992 so as to introduce cardamom as a mixed crop ( $M_2$ ). After removing alternate rows, coffee could get a spacing of 4.2 m x 2.1 m. The inter row spacing of 4.2 m was used for planting cardamom seedlings during June, 1992 in a single hedge row at 1.5 m apart (within a row).



R. coffee + Cardamom mixed cropping system

Regular cultural operations, irrigation and plant protection measures as per schedule were taken up in cardamom and coffee. Besides the application of well decomposed coffee pulp, @ 3 tonnes per ha., recommended dose of fertilizer was applied. Over head (sprinkler) irrigation was provided from the last week of February up to middle of May at an interval of 15 days in each cropping season so as to get 37.5 mm rainfall in each round. Cardamom was harvested from July to January at an interval of 15 days, dried in the flue pipe kiln and processed.

Arabica coffee was harvested during January, whereas the robusta coffee was harvested during February and resorted to wet pulping. The pulped beans were dried on the RCC drying yard in open sun.

The photosynthetically active radiation (PAR) was recorded by using Leaf Chamber Analyser (LCA-3). The horizontal rooting pattern of both robusta coffee and cardamom were studied by water jet washing method. The vertical depth of roots of these crops was observed by cutting the soil profile and by washing the roots from surface to the lowest tips by water jet method to expose the roots. The concentration of both horizontal spread and vertical penetration of the roots were taken in five locations and the pooled average length of the penetration was worked out in both robusta coffee and cardamom.

Economic analysis was carried out to know the profitability of the mixed cropping system. The profitability measures viz., Net Present Worth (NPW) and Benefit-Cost Ratio were computed using the discount rate of 18%.

## RESULTS AND DISCUSSION

### Light utilization pattern

#### Robusta coffee + cardamom

In this multistoreyed cropping system, the tall overhead shade trees (15 m) with well spread canopies formed the top most tier, cardamom (2.8 m) constituted the second tier and robusta coffee (2.0 m) the third or lowermost tier. Mono crop of robusta coffee recorded a photosynthetically active radiation (PAR) of 1188.80  $\mu\text{mol m}^{-2} \text{sec}^{-1}$ . In the mixed crop combination, cardamom recorded a PAR of 792.50  $\mu\text{mol m}^{-2} \text{sec}^{-1}$  followed by robusta coffee 787.50  $\mu\text{mol m}^{-2} \text{sec}^{-1}$ .

#### Arabica coffee + cardamom

In this system, the tall over head shade trees (8-15m) with well spread canopies formed the top most tier, cardamom (2.25-2.75 m) constituted second tier and arabica coffee (1.95-2.15 m) the third or lowermost (ground) tier and they tapped solar radiation at different heights of aerial space. Arabica coffee as a mono crop recorded the highest photosynthetically active radiation



A. coffee + cardamom mixed cropping system

(PAR) of 871  $\mu\text{mol m}^{-2} \text{sec}^{-1}$ . In the mixed cropping system of arabica coffee and cardamom, cardamom recorded a PAR of 801  $\mu\text{mol m}^{-2} \text{sec}^{-1}$ , followed by arabica coffee (784  $\mu\text{mol m}^{-2} \text{sec}^{-1}$ ). Thus, in the mixed cropping systems, different crops tap solar radiation at varying vertical heights above the ground (air space) and effectively utilised available light energy.

#### Rooting pattern and soil coverage

The foraging capacity of rhizosphere of a crop decides effective soil moisture absorption, uptake of nutrients besides providing adequate anchorage.

**Robusta coffee + cardamom:** In robusta coffee, feeder roots were found to concentrate very close to the surface of the ground in most of the plants with an effective horizontal spread in a radius of 50-75 cm. The tap root was observed to be extensively branched and generally short 75-95 cm. Rooting pattern of robusta coffee revealed that 75% of the ground area was left unexploited by their rhizosphere. Hence, the left over space provided a vast scope to accommodate quick yielding mixed crop of cardamom which has a shallow root system by adjusting the planting pattern (Fig.1).

**Arabica coffee + cardamom:** Arabica coffee produced most of the roots in the region deeper than that of cardamom. The arabica coffee roots were found to grow deeper (70-90 cm) and cover 50-60 cm radius around the base. Nearly 75% of the ground area was left unexploited in the rhizosphere of arabica coffee.

It was observed that the bearing cardamom clumps had a concentration of 80% of lateral roots spread within 25 cm radius, from the outer circle of the clump. Vertically cardamom roots could penetrate upto 40 cm. Hence, the left-over space provided a vast scope to accommodate quick

yielding mixed crop of cardamom which has a shallow root system (Fig. 2).

Thus, coffee with a tap root and cardamom possessing shallow fibrous root system could absorb the soil nutrients and moisture at varying depths in the mixed crop combination.

#### Yield pattern

##### Robusta coffee + cardamom:

Dry yield of coffee per plant was significantly higher when it was grown as a mixed crop with cardamom (2.902 kg/plant) with half the population (686 plants/ha) compared to mono crop (2.025 kg/plant) with full complement of population of 1372 plants/ha, whereas dry yield per hectare of robusta coffee was significantly higher when it was grown as mono crop (2626 kg/ha) compared to mixed crop (1988 kg/ha) with cardamom (Table 1). By removing alternate row of robusta coffee to introduce cardamom as a mixed crop, the coffee bushes could get sufficient space for development of lateral branches and building up well spread frame (canopy) by better tapping of solar radiation resulting in the enhanced photosynthetic activity and yield. That is how the yield per plant of coffee was higher when it was mix cropped with cardamom compared to per plant yield in the mono crop.

Dry yield per plant and per hectare varied significantly among years. Dry yield per plant was highest in the year 1992-93 (2.95 kg/plant) followed by the year 1986-87 (2.94 kg/plant), 1990-91 (2.75 kg/plant) and 1991-92 (2.50 kg/plant). It was lowest in the year 1989-90 (2.00 kg/plant). Similarly dry yield per hectare was the highest during the year 1992-93 (2813 kg/ha) and lowest during 1989-90 (1963 kg/ha).

Cropping systems interacted significantly with year for yield per plant and not for yield per hectare. Dry yield of

Table 1. Dry yield of robusta coffee grown as mono crop and mixed crop with cardamom

Year	Yield (Kg/plant)			Yield (Kg/ha)		
	Mixed crop	Mono crop	Mean	Mixed crop	Mono crop	Mean
1985-86	2.40	1.78	2.09	164	2443	2045
1986-87	3.61	2.28	2.94	248	3125	2803
1987-88	2.88	1.66	2.26	196	2285	2123
1988-89	2.53	2.00	2.27	173	2750	2243
1989-90	2.28	1.72	2.00	156	2360	1963
1990-91	2.62	2.37	2.50	180	2575	2188
1992-93	3.62	2.29	2.95	248	3145	2813
1993-94	3.04	1.76	2.40	2065	2415	2240
Mean	2.90	2.02	-	1988	2626	-
	F test	SEm $\pm$	CD at 5%	F test	SEm $\pm$	CD at 5%
Cropping system	**	0.039	0.117	**	64.2	192
Year	**	0.083	0.248	**	136.2	407
Interaction	**	0.118	0.351	NS	192.6	-

\*\* Significant at 1%  
NS Not Significant

robusta coffee per plant was highest in the year 1992-93 (3.62 kg/plant) when grown as mixed crop with cardamom followed by the year 1986-87 (3.61 kg/plant), 1990-91 (3.15 kg/plant) and 1993-94 (3.04 kg/plant).

Dry yield of cardamom per plant and per hectare varied significantly with years. Maximum yield was obtained in the year 1988-89 (605.0g/plant, 1400.5 kg/ha) followed by the year 1989-90 (229.7 g/plant, 531.75 kg/ha). It was the lowest (197.8 g/plant, 457.8 kg/ha) during the year 1991-92 (Table 2).

In cardamom the highest yield is generally obtained either during third or fourth year after planting, then it comes down and attains an average yield plateau more so in Malabar types. Even in this case, the highest crop yield was recorded during the fourth year of planting which came down in succeeding crop (1989-90) by 45.21%. One of the reasons for low yield after attaining highest yield may be due to the fact that cardamom is a rhizomatous crop and majority of buds (65%) would express their full

potentiality due to conversion of most of the suckers (buds) into bearing suckers (pseudostems) in a particular year (3rd or 4th year after planting) during which the highest yield was obtained. Then the yield comes down substantially in succeeding crop seasons. The suckers which would have already undergone production die during the following season by giving rise to sister/daughter suckers (Korikanthimath, 1995). The average yield of cardamom mix cropped with robusta coffee for seven crop

Table 2. Dry yield of cardamom grown as mixed crop with robusta coffee

Year	Yield (g/plant)	Yield (kg/ha)
1987-88	216.2	500.45
1988-89	605.0	1400.50
1989-90	331.5	767.35
1990-91	229.7	531.75
1991-92	197.8	457.80
1992-93	230.5	533.60
1993-94	223.2	516.65
F test	**	**
S.E.m $\pm$	24.45	113.21
C.D. at 5%	67.8	156.90

\*\* Significant at 1%

seasons (672.60 kg/ha), has been found to be quite remarkable due to conducive development of micro climate in the cropping system.

#### Arabica coffee + cardamom

Dry yield per plant and per hectare was significantly higher when arabica coffee was grown as mono crop (789.8 g/plant, 1790.3 kg/ha) with full complement of plant population (2268 plant/ha) compared to mixed cropping with cardamom (525.0g/ plant, 574.7 kg/ha) with half the population (1134 plants/ha). Dry yield per plant and per hectare varied significantly over the years (Table 3). Dry yield of arabica coffee was the highest during 1993-94 (886.9 g/plant, 1572.9 kg/ha) followed by 1994-95 (672.8 g/plant, 1170.1 kg/ha) and it was the lowest during 1992-93 (412.5 g/plant, 804.4 kg/ha). Cropping systems interacted significantly with years for yield per plant but not for yield per hectare. Highest yield per plant was obtained during 1993-94 (1001.8 g/plant) when arabica coffee was grown as mono crop followed by the year 1994-95 (772.5 g/plant) as mono crop and 1993-94 (772.0 g) as mixed crop with cardamom.

By and large arabica coffee had a high and low crop yielding tendency both in mono

and mixed crop situations on alternate years. The drop in the yield per plant when mix cropped with cardamom was pronounced more during the first year of introducing cardamom (1992-93), due to the pruning of side branches of coffee bushes to allow sufficient sunlight to newly planted cardamom seedlings for better establishment and profilation of suckers. During the second year of the study (1993-94), the yield per plant of arabica coffee improved substantially. The comparatively low yield per plant observed during the third year (1994-95) was due to the vigorous growth of cardamom plants resulting in partial shading of arabica coffee. The yield obtained during the said year in cardamom was highest (626 kg/ha). Subsequently the trashing operation carried thrice a year in cardamom would not cause any shading effect on arabica coffee in the system.

Yield of cardamom per plant and per hectare varied significantly with years (Table 4). Dry cardamom yield was higher during 1994-95 (394.5 g/plant, 626.1 kg/ha) compared with yield during 1993-94 (31.5 g/plant, 49.9 kg/ha). During the very second year of planting, cardamom mix cropped with arabica coffee recorded 49.9 kg/ha which could meet the initial expenditure of the

Table 3. Dry yield of arabica coffee grown as mono or mixed crop with cardamom

Year	Yield (g/plant)			Yield (kg/ha)		
	Mixed crop	Mono crop	Mean	Mixed crop	Mono crop	Mean
1992-93	230.0	595.0	412.5	260.2	1348.6	804.4
1993-94	772.0	1001.8	886.9	874.7	2271.2	1572.9
1994-95	573.0	772.5	672.8	589.1	1751.1	1170.1
Mean	525.0	789.8	-	574.7	1790.3	--
	F test	SEm±	CD at 5%	F test	SEm±	CD at 5%
Cropping system	**	16.77	46.5	**	37.22	103.2
Year	**	20.54	56.9	**	45.59	126.4
Interaction	*	59.04	NS	64.47	--	

\*\* Significant at 1%  
\* Significant at 5%

Table 4. Dry yield of cardamom grown as mixed crop with arabica coffee

Year	Yield (g/plant)	Yield (kg/ha)
1993-94	31.5	49.9
1994-95	394.5	626.1
C.D at 5%	38.8	61.6

establishment and maintenance. The highest crop of 626.1 kg/ha was observed during the third year of its planting (1994-95).

In cardamom the highest yield is generally obtained during the third year after planting. One of the reasons for highest yield during third year is due to the fact that cardamom being a rhizomatous crop, 65% of vegetative buds could express their full potentiality due to conversion of most of the buds in to bearing tillers within a period of 18-30 months (Korikanthimath, 1995).

#### Economics

##### Robusta coffee + cardamom

The average (9 years) cost of cultivation of mixed cropping was higher by 50.57% compared to monocropping of robusta coffee. This was due to intensive cultural operations for cardamom and high

labour requirement for harvesting operation of cardamom (Table 5).

Gross returns in the initial years (1985-86 & 1986-87) was less in mixed cropping of robusta coffee with cardamom than the monocropping. This was due to prebearing stage of cardamom and less yield of coffee due to pruning and removal of alternate row of coffee plants. However, from the Table 6 it was apparent that, on an average the gross and net returns were more by 5.17 and 4.06 times respectively compared to monocropping.

The Net Present Worth (NPW) and Benefit Cost Ratio (BCR) were higher in mixed cropping by 232.75 and 74.18% respectively (Table 5). This indicates the superiority with respect to profitability of mixed cropping of robusta coffee with cardamom over monocropping of robusta coffee.

##### Arabica coffee + cardamom

The economics of this crop combination revealed that there was an increasing trend with respect to gross and net returns and cost of cultivation in the mixed cropping (Table 7). On an average the cost of cultivation incurred in mixed and mono cropping were Rs 55002 and

Table 5. Cost and returns of mixed cropping of robusta coffee with cardamom v/s monocropping of robusta coffee (Rs./ha)

Sl. No.	Year	Cross returns		Cost of cultivation		Net returns		Incremental net gain/loss	Percentage Net gain/loss
		Mixed cropping	Mono crop	Mixed cropping	Mono crop	Mixed cropping	Mono crop		
1	85-86	35623	52895	17550	15588	18073	37307	- 19234	- 51.55
2	86-87	44382	56462	20375	18983	24007	37479	- 13472	- 35.94
3	87-88	165133	46788	36487	20510	128646	26278	102368	389.56
4	88-89	220134	66984	48984	25383	171150	41601	+ 129549	+ 311.41
5	89-90	218284	39570	37869	23768	180415	14802	+ 164613	+ 1041.72
6	90-91	156661	59647	39655	27890	117006	31757	852459	268.44
7	91-92	167169	52353	40454	27978	126715	24375	+ 102340	+419.86
8	92-93	319354	81876	57425	40302	261929	41574	+ 220355	+ 530.03
9	93-94	319571	99915	63313	40139	256258	59776	196482	328.70
	Average	182923.44	61832.22	40234.67	26726.8	142689	35105.42	+107584	+306.46

**Table 6. Comparative economics of mixed vs monocropping of robusta coffee**

Sl. No.	Particulars	Mixed cropping (Robusta coffee + Cardamom)	Monocropping of Robusta coffee
1.	Discounted gross returns (Rs./ha)	639045	248537
2.	Discounted cost of cultivation (Rs./ha)	150471	101693
3.	NPW (Rs./ha)	488573	146844
4.	BCR	4.25	2.44

**Table 7. Economics of mono and mixed cropping of arabica coffee with cardamom**

Sl. No.	Year	Gross returns		Cost of cultivation		Net returns (Rs/ha)	
		Mono crop	Mixed crop	Mono crop	Mixed crop	Mono crop	Mixed crop
1.	1992-93	27,000	16,200	23,973	43,370	3,027	-27170
2.	1993-94	56800	64250	29176	51075	27624	13175
3.	1994-95	46200	273250	31196	70560	16004	202690
Total		130000	353700	84345	165005	46655	188695
Average		43333	117900	28115	55002	15552	62698
		<b>Mono crop</b>	<b>Mixed crop</b>				
(1) BCR		1.54	1.94				
(2) NPW(Rs./ha)		32144	109800				

28115/ha per year respectively. Further the gross and net returns were higher in the mixed cropping by 172.08 and 303.15% compared to monocropping of arabica coffee. The BCR (1.94) and NPW (Rs. 109800) also placed the mixed cropping in the higher order, indicating the advantage of mixed cropping of arabica coffee with cardamom compared to mono cropping of arabica coffee. The study was in conformity with earlier observations of Srinivasan *et al.* 1992.

In summary, cardamom which is a high value and low gestation (24 months) crop, can be grown successfully in single hedge as mixed crop with arabica coffee and in double hedge as a mixed crop with robusta coffee to increase the production and productivity per unit area and time by sharing of irrigation and other common

cultural operations like weeding, mulching, shade regulation etc. in a typical "Silvi - plantation - agro forestry system". As 70% of cardamom and 80% of coffee plantation have less than 2 ha of land, the economic returns can be enhanced from mix cropping of both these crops in an ideal situations under assured irrigation without needing further expansion of area as there has been a pressure on land in the recent years. Amongst various cash inputs, labourers constituted 60%. Labour force could be very

effectively utilized amongst routine cultural operations mainly for harvesting cardamom over seven months (July to January) and for robusta coffee picking in February thus ensuring flow of returns over eight months in a year.

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