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Mixed cropping of arabica coffee and cardamom : Influence on micro climatic and physiological characteristics

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Abstract

The experiment was conducted in Chettali, a predominant coffee growing area in Kodagu District, Karnataka, India, to study the suitability of cardamom (*Elettaria cardamomum* Maton) as mixed crop with arabica coffee (*Coffea arabica* L.). Data on micro climatic and physiological characteristics were recorded using leaf chamber analyser (LCA-3). Light intercepted by cardamom was more than the arabica coffee in mixed cropping system. Photosynthetic rate, transpiration rate, stomatal conductance were higher in cardamom than arabica coffee. Arabica coffee recorded higher water use efficiency and lower carboxylation efficiency. The data suggests that cardamom and arabica coffee are competing each other for environmental factor. Therefore, they may not be suitable for mixed cropping system in the long run because of height factor and growth habit even though net returns are higher in mixed cropping system.

Key words : Arabica coffee, cardamom, microclimate, mixed cropping, physiology.

Introduction

In coffee plantations, cropping strategy has to be on the lines of multistoryed cropping system, which aims at raising compatible combination of crops having varying morphological frame and rooting habits, grown together in such a manner that their canopies tap sunlight at varying heights and roots absorb moisture and nutrients from soil at different horizons [2,9]. In mixed cropping system, plants compete for light, water, soil and space. Competition initiates when the immediate supply of a single necessary factor falls below the combined demands of the plants [4].

The mixed crop with shaded canopies will continue to grow and adjust themselves to low light levels. Mechanisms for adaptation to low light intensity include reduced rates of dark respiration [7], lowered roots to shoot ratio [3] and a greater leaf area/leaf weight ratio [7]. These changes increase the interception of light and reduce the respiratory load. The CO_2 environment does not change enough at the base of dense plant canopies to affect CO_2 uptake because photosynthetically active radiation rather than CO_2 limits photosynthesis at the bottom of the canopies [8]. In this study efforts are made to see the effect of mixed cropping of cardamom with arabica coffee on micro climatic and physiological characteristics.

Materials and methods

The trial was conducted to study the compatibility and productivity of arabica coffee and cardamom in mixed cropping system at Chettalli, Kodagu District, Karnataka, India. Alternate rows of coffee (planted in 1982) were removed in 1992 so as to introduce cardamom as a mixed crop. The soils of the experimental site were sandy loam and classified as kandic paleustaf type. The soils were moderately acidic, rich in organic matter, low in available phosphorus and medium in available potash. The average rainfall was 1400 mm with 125 rainy days per annum wherein nearly 2/3rd of precipitation is received during the south west monsoon. Experiment was laid out in radomised block design with eight replications and three treatments i.e., monocropping of arabica coffee (selection No. 795, 2.1m x 2.1m spacing), mixed cropping of arabica coffee (4.2m x 2.1 spacing) and cardamom (C1-37, Malabar type, 4.2m x 1.5m spacing). Cardamom was planted between the rows of arabica coffee. Each treatment was planted in 4000 m^2.

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Table-1. Micro climatic parameters in arabica coffee and cardamom in mixed cropping system

Parameters	Monocropping	Mixed cropping		CV	LSD
	Arabica coffee	Arabica coffee	Cardamom	(%)	(P-0.05)
1. Light interception(%)	63.6	57.2	58.5	6.6	4.2
2. PAR (µmol $m^{-2}sec^{-1}$)	871.3	783.9	801.2	1.3	11.6
3. Relative humidity (%)	43.2	52.6	52.5	5.6	2.8
4. Air temperature (^oC)	27.9	26.2	25.6	7.7	2.2
5. Leaf temperature (^oC)	26.7	25.8	23.3	8.3	2.2

Table-2. Changes in physiological characteristics in arabica coffee and cardamom mixed cropping system

Parameters	Monocropping	Mixed cropping		CV	LSD
	Arabica coffee	Arabica coffee	Cardamom	(%)	(P-0.05)
1. Photosynthetic rate ($\mu molCO_2 m^{-2}sec^{-1}$)	4.8	3.6	4.1	7.2	0.3
2. Transpiration rate ($\mu molCO_2 m^{-2}sec^{-1}$)	5.5	2.6	8.1	5.6	0.3
3. Stomatal conductance ($\mu molm^{-2}sec^{-1}$)	0.36	0.12	0.48	11.0	0.04
4. Intercellular CO_2 (ppm)	320.1	282.6	353.4	1.2	4.1

The measurements were recorded on physiological parameters viz. photosynthetic rate (A) (µmol CO_2 $m^{-2}sec^{-1}$), transpiration rate (E) (µmol H_2O $m^{-2}sec^{-1}$), stomatal conductance (g_s) ($\mu molm^{-2}sec^{-1}$), intercellular CO_2 concentration (C_i) ($\mu molCO_2 m^{-2}sec^{-1}$), and micro climatic parameters such as light interception (%), photosynthetically active radiation (PAR) (µmol $m^{-2}sec^{-1}$), relative humidity (%), leaf temperature (^oC) and air temperature (^oC), by using Leaf Chamber Analyser (LCA-3) during March 1993-94 from 10-12 AM on fully opened leaves of arabica coffee and cardamom. The ratios of A/E, A/C_i and A/g_s were also computed.

Results and discussion

Micro climate

In perennial plantation crops, the structure of overhead canopy and orientation of leaves in the crown decide the light availability to the ground which can be profitably exploited for raising mixed crop species in multistoreyed cropping systems [9]. In the present study, the overhead shade trees formed the top most storey (first tier) followed by arabica coffee in a initial years is second tier and cardamom the third tier system. After one year of planting cardamom could reach second tier and arabica coffee will form lower tier.

Table-3. Mean values A/E, A/g_s and A/C_i in arabica coffee and cardamom mixed cropping system

Parameters	Monocropping	Mixed cropping		CV	LSD
	Arabica coffee	Arabica coffee	Cardamom	(%)	(P-0.05)
1. A/E	0.89	1.39	0.51	6.4	0.06
2. A/g_s	13.83	30.86	8.41	16.1	3.04
3. A/C_i	0.015	0.013	0.011	7.17	0.001

Table-4. Dry yield of arabica coffee and cardamom in mono and mixed cropping system

Crop	Yield (g/plant)		Yield (kg/ha)	
	Mono crop	Mixed crop	Mono crop	Mixed crop
1. Arabica coffee	1001.8	772.0	2271.1	874.7
2. Cardamom	–	31.5	–	49.9

The data on micro climatic variables such as light interception, relative humidity, PAR, air temperature and leaf temperature are presented in Table-1. Micro climatic parameters showed significant variation in the cropping system. Monocrop of arabica coffee recorded 63.6 per cent light interception which is significantly higher than the mixed cropping of arabica coffee and cardamom. Light intercepted by cardamom (58.5%) and arabica coffee (57.2%) are on par with each other in mixed cropping system.

Photosynthetically active radiation (PAR) received by monocrop of arabica coffee (871.3 µmol $m^{-2}sec^{-1}$) was significantly higher than mixed crop of cardamom and arabica coffee as mixed crops. Cardamom received 801.2 µmol $m^{-2}sec^{-1}$ whereas arabica coffee received 783.9 µmol $m^{-2}sec^{-1}$. The higher PAR received in cardamom was due to increased height of cardamom in third year.

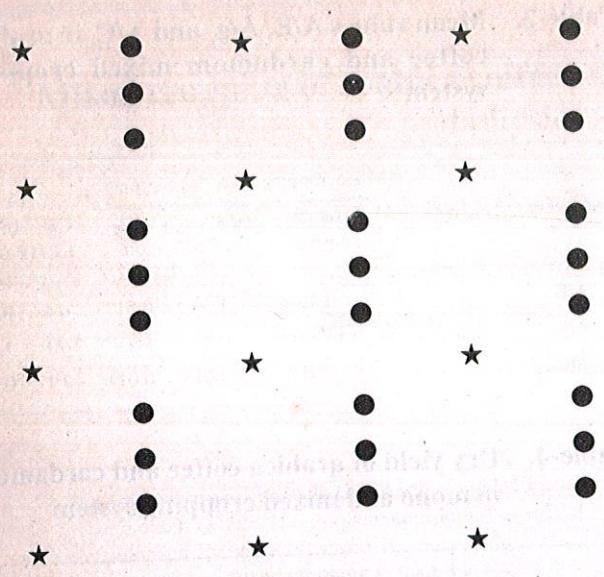

Figure 1. Planting pattern of arecanut and cardamom mixed cropping system

Index to crops	Spacing	Density/ha
★ Arecanut	2.7m x 2.7m	1372
● Cardamom	2.7m x 1.2m	3086
	Total	4458

Relatively humidity was very low in monocrop of arabica coffee (43.2%) compared to mixed cropping system (52.5%). It is due to comparatively more openness in a monocrop situation. The study clearly indicated that crop combination creates congenial climate for the growth and development of component crops. Air temperature ranged from 25.6 to 27.9°C which was not significantly different and leaf temperture ranged from 23.3 to 26.7°C. Monocrop of arabica coffee had a significantly higher leaf temperature compared to cardamom. It was due to high light interception and low relative humidity.

Physiological parameters

The data on photosynthetic rate and its related parameters in mixed cropping system is presented in Table-2. All the parameters studied showed significant variations. The photosynthetic rate was higher in monocrop of arabica coffee (4.8 µmol CO_2 m^{-2} sec^{-1}) compared to the mixed crop of arabica coffee (3.6 µmol CO_2 $m^{-2}sec^{-1}$). Cardamom showed 4.1 µmol CO_2 $m^{-2}sec^{-1}$) in a mixed crop system. Cardamom recorded higher transpiration rate (8.0 µ mol $H_2Om^{-2}sec^{-1}$) compared to monocrop of arabica coffee (5.5 µ mol H_2O $m^{-2}sec^{-1}$) which was also reflected in stomatal conductance and intercellular CO_2 concentration (353.4 ppm). Stomatal conductance ranged from 0.12 to 0.485 µ mol $m^{-2}sec^{-1}$, whereas intercellular CO_2 concentration ranged from 282.6 to 353.4 ppm.

A/C_i which indicated the carboxylation efficiency [5] and A/E and A/g_s indicate the intrinsic water use efficiency of crop plants. Mixed crop of arabica coffee recorded higher water use efficiency and lower carboxylation efficiency at gas exchange level (Table-3), which indicates the survival strategy of arabica coffee under competition by cardamom as mixed crop. Monocrop of arabica coffee recorded 874g/plant whereas mixed crop yield was 772g/plant in addition to cardamom 31.5g/plant dry capsules in second year of planting cardamom (Table-4). Even though cardamom and arabica coffee in the mixed cropping system are having monitory benefit, they are competing each other for environmental factors. Earlier studies on cashew and associated crops also indicated similar results [1].

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