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Microclimatic and physiological analysis in coffee-cardamom mixed cropping system

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Abstract

Experiments were conducted at Chettalli (Karnataka, India) to study microclimatic and gas exchange parameters in coffee (*Coffea robusta*) and cardamom (*Elettaria cardamomum*) mixed cropping system. Coffee in monocrop and mixed cropping systems recorded higher light interception, photosynthetically active radiation, net photosynthetic rate and transpiration rate compared to cardamom. In the mixed cropping system, cardamom received 57.8% light and almost equal amount of photosynthetically active radiation.

Key words: cardamom, coffee, microclimate, mixed cropping, physiological parameters.

In mixed cropping systems, plants compete for light, water, soil and space. Competition is initiated when the immediate supply of a single necessary factor falls below the combined demands of the plants (Donald 1963). The spectral qualities of radiation changes with the depth of penetration in plant canopies because leaves absorb solar radiation differently. In a mixed cropping system with shaded canopies the plants adjust themselves to low light levels. Mechanisms for adaptation to low light intensity include reduced rates of dark respiration (Kumura 1968), lowered root to shoot ratio (Brouwer 1966) and greater leaf area/leaf weight ratio (Iwaki 1959). 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 (Nair 1979). The effect of mixed cropping of cardamom (*Elettaria cardamomum* Maton) with robusta coffee (*Coffea robusta* Linden) on microclimate and gas exchange parameters was studied at Chettalli (Kodagu District, Karnataka, India) and the results are reported here.

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An alternate row of coffee (which was originally planted during 1947) was removed to introduce cardamom as mixed crop. The spacing of coffee was 5.4 m x 2.7 m. 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 as a paired row (double hedge system) in the centre of coffee plants (rows) by leaving 1.8 m on either side of the coffee rows. The experiment was laid out in a completely Randomised Block Design with eight replications and three treatments. The data was analysed by two way analysis of variance.

Physiological parameters namely, photosynthetic rate (A), transpiration rate (E), stomatal conductance (g_s) and intercellular CO_2 concentration (C_1) and microclimatic parameters such as light interception, Photosynthetically Active Radiation (PAR), Relative Humidity and leaf and air temperature were determined by using Leaf Chamber Analyser (LCA-3) during March 1993-94 during 10-12 am in fully opened leaves of both coffee and cardamom. The ratios of A/E, A/C_i and A/g_s were also calculated.

Microclimate

Monocrop of coffee received higher amount of light (86.8%) compared to that in mixed cropping system (57.5%). In mixed cropping, cardamom intercepted 57.8% light due to mutual shading by the canopies of both the crops. Similar results were reported in high density cropping systems in cashew (Balasimha & Yadukumar 1993). Monocrop of coffee received significantly higher amount of PAR (1188.8 µ $molm^{-2}s^{-1}$). Relative humidity and leaf and air temperature in the mixed cropping system did not vary significantly. Relative humidity ranged from 23.6 to 24.0%; air and leaf temperature ranged from 27.3-29.4°C and 29.6-30.0°C respectively, in the mixed cropping system (Table 1).

Physiological parameters

The photosynthetic rate, transpiration rate, stomatal conductance and intercellular CO_2 concentration showed significant variations in cropping systems of cardamom and coffee. The photosynthetic rate was 4.2 $\mu molCO_2m^{-2}s^{-1}$ in monocrop of coffee compared to 2.9 µmol $CO_2m^{-2}s^{-1}$ in coffee grown as a mixed crop. A 45% increase in photosynthetic rate was observed in monocrop of coffee due to higher light availability; cardamom recorded a photosynthetic rate of 3.2 $\mu molCO_2m^{-2}s^{-1}$ which was lower than

Table 1. Microclimatic variables in coffee and cardamom mixed cropping system

Cropping system	Light interception (%)	PAR ($\mu molm^{-2}s^{-1}$)	Relative humidity (%)	Air temp. (°C)	Leaf temp. (°C)
Coffee as monocrop	86.8	1188.8	23.6	29.4	30.9
Coffee as mixed crop	57.4	787.5	24.0	27.3	29.6
Cardamom as mixed crop	57.8	792.5	24.0	27.3	30.0
C V (%)	3.0	3.8	7.3	11.0	9.4
LSD (P=0.05)	2.2	37.9	NS	NS	NS

NS = Not significant

Table 2. Gas exchange parameters in coffee and cardamom mixed cropping system

Cropping system	Photosynthetic rate ($\mu molCO_2m^{-2}s^{-1}$)	Transpiration rate ($\mu molH_2Om^{-2}s^{-1}$)	Stomatal conductance ($molm^{-2}s^{-1}$)	Intercellular CO_2 (ppm)
Coffee as monocrop	4.2	5.9	0.17	331.5
Coffee as mixed crop	2.8	4.4	0.24	315.2
Cardamom as mixed crop	3.2	5.4	0.22	312.0
C V (%)	6.1	13.3	19.22	4.1
LSD (P=0.05)	0.2	0.7	0.04	14.1

the monocrop of coffee and higher than mixed crop. The transpiration rate (5.9 $\mu molH_2Om^{-2}s^{-1}$) was higher in monocrop of coffee compared to mixed crop (4.4 $\mu molH_2Om^{-2}s^{-1}$). Stomatal conductance was low in the monocrop than in mixed crop. The internal CO_2 concentration was higher in monocrop than mixed crop of coffee and cardamom (Table2).

Coffee as a monocrop showed higher water use effciency (A/E) and also carboxylation efficiency (A/C_i) than as mixed crop (Table 3). In mixed cropping systems the plants compete with each other for inputs which alters physiological processes. The yield of coffee was lower (1.749 kg/plant) as a monocrop compared to mixed crop (3.041 kg/plant).

Table 3. Mean values of A/E, Ag_s, A/C_i in coffee and cardamom mixed cropping system

Cropping system	A/E	A/g_s	A/C_i
Coffee as monocrop	0.707	25.23	0.013
Coffee as mixed crop	0.673	12.37	0.009
Cardamom as mixed crop	0.603	14.84	0.010
C V (%)	16.050	20.66	8.800
LSD (P=0.05)	0.114	3.87	0.001

A = Photosynthetic rate; E = Transpiration rate; g_s = stomatal conductance; Ci = Intercellular CO_2 concentration

The study indicates that coffee-cardamom mixed cropping systems are compatible and the productivity of these crops could be increased by resorting to intensive mixed cropping.

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