

NET PHOTOSYNTHESIS OF COCOA GROWN UNDER ARECANUT

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ABSTRACT

The net photosynthetic rate (P_n), canopy/leaf area and potential canopy P_n were studied in cocoa trees grown under arecanut palms at six planting densities. The microclimatic variables, P_n , stomatal conductance and transpiration rate did not show significant treatment effects. As light was equal or more than the saturating levels, the PN of leaves were not affected. However, the canopy/leaf area and canopy P_n were significantly higher in wider spaced cocoa trees. The leaf area index did not differ significantly between treatments and was in the range of 7.1 to 9.8. Thus, the variation in leaf area and whole plant photosynthetic potential are powerful determinants of productivity in cocoa.

INTRODUCTION

The studies on photosynthesis in trees have been done mostly among the temperate species (Schaedle, 1975). Among tropical tree crops, photosynthetic characteristics have been analyzed in recent years, due perhaps to the advancements made in portable infra-red gas analysers. The net photosynthetic rate (P_n) was studied in coffee (Nunes, 1988), tea (Squire and Callander, 1981), cocoa (Balasimha, *et al.*, 1990; Joly and Hahn, 1989), rubber (Samsuddin and Impens, 1978; Sathcesan *et al.* 1984) and cashew Balasimha, unpublished). In Southern India, cocoa is cultivated as a mixed crop with arecanut palms as the environmental conditions are favourable for its growth. The growth and performance of cocoa and arecanut under mixed cropping system were evaluated (Shama Bhat, 1988). The present paper describes the analytical approach on the effect of planting densities with reference to P_n and canopy characters of cocoa.

MATERIALS AND METHODS

The agronomic trial of mixed crop of cocoa (*Theobroma cacao* Linn.) and arecanut (*Areca catechu* Linn.) was planted in 1970 with six spacing treatments viz., both arecanut and cocoa at 2.7 x 2.7 m (S_1); arecanut at 2.7 x 2.7 m and cocoa at 2.7 x 5.4 m (S_2); arecanut at 2.7 x 2.7 m and cocoa at 5.4 x 5.4 m (S_3); both arecanut and cocoa at 3.9 x 3.9 m (S_4); both arecanut and cocoa at 3.3 x 3.3 m (S_5); arecanut at 1.8 x 5.4 m and cocoa at 3.6 x 5.4 m.

Four trees in each treatment were selected from the replicates at random for canopy and P_n measurements. The trees were fertilized annually with 100 g N, 40 g P_2O_5 , 140 g K_2O and irrigated every ten days during dry months. The estimations of canopy area, leaf area and leaf area index (LAI) were made as described earlier (Balasimha and Nair, 1989). Measurements of light (PAR), temperature (T_{air}), relative humidity (RH), VPD, P_n , intercellular CO_2 , stomatal conductance (gs) and transpiration rate (E) were made in 3 to 5 mature leaves of other canopy per tree using LI-6200 portable photosynthetic system (LI-COR, 1987). Two observations were recorded for each leaf, enclosing upto 30 cm² leaf area in one liter chamber. The instantaneous water use efficiency (WUE) was also calculated. All the measurements were made between 10.00 and 12.00 h during October 1988 and 1989 and pooled data were analysed statistically.

RESULTS AND DISCUSSION

The microclimatic variables recorded in the six planting densities are given in Table I. There was an increase in PAR in wider cocoa spacings (S_3 to S_5). However, neither PAR nor other microenvironmental parameters (T_{air} , RH and VPD) showed any significant differences. Similarly, there were no significant differences in P_n and related parameters (Table II). The S_3 and S_4 treatments showed higher P_n and E_n though it was not significant when statistically analysed. The light saturation of P_n occurs at 350-400 mol m⁻²s⁻¹ (Balasimha *et al.*, 1990; Rajaharun

and Hardwick, 1988). Since all the spacings of the arecanut - cocoa mixed cropping received PAR above this level, no significant changes in photosynthetic characteristics were discernible.

The canopy and leaf area and canopy P_N showed

Table I. Effect of spacing treatments on Microclimate in Arecanut-Cocoa mixed crop

Treatment	PAR ($\mu\text{mol m}^{-2}\text{s}^{-1}$)	Tair ($^{\circ}\text{C}$)	RH (%)	VPD (mbar)
S ₁	368.5	32.60	63.33	18.55
S ₂	392.7	31.79	68.63	14.58
S ₃	857.0	34.32	52.30	27.66
S ₄	734.7	32.43	57.97	23.01
S ₅	911.2	32.68	57.71	23.48
S ₆	959.5	33.19	64.05	19.91
S.E.	353.2	0.99	10.62	7.90

highly significant differences among the treatments (Table III). These characters were significantly higher in wider spacings, the highest values being observed in S₆. Thus, the leaf area takes a dominant role in cocoa and photosynthetic potential of the whole plant ($P_N \times$ leaf area) is more important for the productivity. The variation in leaf area is a more powerful determinant of yield than variations in P_N on unit leaf basis (Gifford and Evans, 1981). In fact significantly higher yields per tree were obtained in S₂, S₃ and S₆ treatments (Shama Bhat, 1988). Considering the economic and operational advantages, S₂ which gave maximum yield on a hectare basis can be recommended in the normal arecanut spacing of 2.7 x 2.7 m (Shama Bhat, 1988). The LAI of individual cocoa trees did not differ significantly between the treatments (Table III), which may be attributed to the regular pruning followed in the closer spacings. The total LAI per hectare for arecanut + cocoa were 23.0, 19.3, 9.6, 18.2, 20.5 and 16.6 for S₁ to S₆ respectively. Thus, the maximum

Table II. Effect of spacing treatments on photosynthetic characters of cocoa

Treatment	P_N ($\mu\text{mol CO}_2\text{m}^{-2}\text{s}^{-1}$)	gs (mol $\text{m}^{-2}\text{s}^{-1}$)	Intercellular CO_2 (ppm)	E (mmol $\text{m}^{-2}\text{s}^{-1}$)	WUE ($\mu\text{mol CO}_2/\text{mol H}_2\text{O}$)
S ₁	4.95	0.31	271.5	4.36	1.31
S ₂	3.96	0.47	290.7	4.87	0.80
S ₃	4.35	0.24	273.0	5.25	0.84
S ₄	3.51	0.25	282.0	3.98	0.86
S ₅	4.99	0.35	277.5	5.27	0.94
S ₆	5.61	0.38	272.0	5.61	1.02
S.E.	1.09	0.16	19.5	0.85	0.29

Table III. Effect of spacing treatments on canopy characters of cocoa

Treatment	Canopy area (m^2)	Leaf area (m^2)	Canopy P_N ($P_N \times \text{LA}$)	LAI	Canopy diameter/height ratio
S ₁	27.43	150.84	658.35	7.71	1.75
S ₂	44.49	246.20	894.67	8.60	1.77
S ₃	39.95	208.80	970.22	8.58	1.69
S ₄	48.65	259.68	972.30	8.51	1.58
S ₅	33.74	205.09	1019.37	9.87	1.63
S ₆	58.21	270.68	1494.92	7.08	1.84
S.E.	8.29	34.95	236.53	1.49	—
C.D.	12.32**	51.93**	351.40**	NS	—

($p=0.01$)

total LAI was recorded in closest spacing (S_1) and least where cocoa population was minimum (S_3). The ratios of canopy diameter to height were consequently more or less uniform, though as expected, it was the highest in S_3 spacing. The greater canopy diameter/height ratio (> 1.0) is characteristic of species evolved as understorey crops and depicts a high degree of shade - tolerance (Givinish, 1988).

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