

EFFECT OF PLANT DENSITY ON PHOTOSYNTHESIS IN CASHEW *

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Received on 23 May, 1992

SUMMARY

The net photosynthesis and related parameters were studied in cashew trees (*Anacardium occidentale L.*) grown at five plant densities. There was significantly higher photosynthesis and transpiration in wider spaced trees parallel with higher irradiances. Stomatal conductance (g_s) did not show significant differences between the plant densities treatments. In cashew, plant density of 625 ha⁻¹ (4x4 m) may be a threshold level for optimising productivity.

INTRODUCTION

The fruits of cashew are produced on the newly formed portion of the canopy. There is little foliage or fruits inside the canopy. Further fruit set and its development is dependent on irradiance (Subbaiah, 1983). In field grown cashew trees, high saturation irradiance is required for optimum net photosynthesis (Balasimha, 1991). Thus by increasing the canopy surface area and optimising the photosynthetic capacity, productivity of the crop can be maximised. In this paper net photosynthesis and related parameters in cashew trees grown at five different plant densities are reported.

MATERIALS AND METHODS

Experiment on high density planting of cashew (*Anacardium occidentale L.*) was started in 1982 at the Experimental Station, Shantigodu (12.25' N, 75.42' E and 90m altitude). There were five spacing treatments viz., 8 x 8m (T₁), 6 x 6 m (T₂), 4 x 4 m (T₃), 3 x 3 m (T₄) and 2 x 2 m (T₅) with density of 156, 278, 625, 1110 and 2500 plants per ha, respectively. The normal spacing adopted for cashew is 8 x 8 m. However, after 7 years, since the canopy in T₄ and T₅ were overlapping, the treatments were modified by thinning it to 550 and 625 plants per ha, respectively (6 x 4.25 m in T₄ and 4 x 4 m in T₅). The trees were raised as rainfed crop (mean annual rainfall was 379.9 cm distributed mainly from June to October) and no irrigation was given during dry months. Temperature ranges between 28-36° C (maximum) and 19-24° C (minimum). The soil was lateritic in nature and fertilizers at the rate of 500 g N, 125 g P₂O₅

and 125 g K₂O per tree were applied annually.

Measurements of irradiance (PFD), temperature of cuvette (T_{air}) and leaf (T_{leaf}), vapour pressure deficit (VPD), net photosynthesis (A), stomatal conductance (g_s) and transpiration rate (E) were made in the leaves using the LI-6200 portable photosynthesis system (Li-Cor Inc. Lincoln, NE with a 1000 cm³ chamber enclosing upto 20 cm² area (Balasimha, 1991). In each case, fully expanded healthy second or third leaves of the most recently hardened flush (representing approximately 1 month of growth) were used. For light interception studies PFD above and below the tree canopy was measured using the same chamber radiometer and computed. Four trees in each treatment were used with at least six leaves from each tree. All the measurements were made between 10.00 and 12.00 h during January/February of 1989 (7th year), 1990 (8th year) and 1991 (9th year). Intercellular CO₂ concentration (C_i) was computed in the LI-6200 using initial values of A, CE, ambient CO₂ concentration and leaf resistance. The ratios of A/E, A/C_i and A/g_s were also calculated.

RESULTS AND DISCUSSION

The microclimatic variables recorded during the years with respect to plant density treatments are given in Table 1. The PFD was significantly higher in T₁ and T₂ than the other treatments. There was no significant difference over the years for T₁, T₂ and T₃, while T₄ and T₅ had low levels during 7th year, but increased during subsequent years and the treatment and year interaction was also significant. This was due to thinning of the trees during 8th year as the light

* Contribution number : NRCC 14

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transmission was very low in T_4 and T_5 , affecting growth and yield. The mean light interception in different treatments is presented in Table II. Since by 8th year the branches began to overlap from adjacent trees, some branches were pruned in T_5 thereafter. In T_4 and T_5 , light interception was 52 and

19%, respectively after thinning (8th year). However, the interception increased to 77 and 74%, respectively in 9th year. Other parameters like T_{air} , T_{leaf} and VPD were significantly higher in T_1 and T_2 , which was because of the canopies being exposed to higher PFD (Table I).

Table I. Microclimatic variables in the leaf chamber during the measurements on cashew

Parameter	Year after planting	Treatment				
		T_1	T_2	T_3	T_4	T_5
PFD ($\mu\text{mol m}^{-2}\text{s}^{-1}$)	7th	1577	1032	763	303	175
	8th	1387	1009	360	1010	1161
	9th	1507	1278	714	1005	943
	L.S.D. T =	308 **	Year = 240*	T x Y = 536*		
T_{air} (°C)	7th	35.76	34.15	33.19	32.94	32.11
	8th	34.96	34.40	32.28	32.78	32.89
	9th	38.65	37.28	35.58	36.69	36.57
	L.S.D. T =	1.30**	Year = 0.69**			
T_{leaf} (°C)	7th	36.80	34.38	32.99	32.49	31.64
	8th	34.62	34.55	31.55	32.63	32.74
	9th	38.98	38.64	35.48	36.68	36.33
	L.S.D. T =	1.30**	Year = 0.77**			
VPD (Kpa)	7th	3.19	2.40	2.32	2.12	1.89
	8th	2.65	2.63	2.03	2.29	2.36
	9th	3.59	3.29	2.60	2.64	2.66
	L.S.D. T =	0.32**	Year = 0.22**			

Significant at $p=0.05$ (*) or $p=0.01$ (**)

Table II. Light interception in cashew plots

Treatment	% light intercepted		
	7th	8th	9th year
T_1	52	56	65
T_2	62	64	67
T_3	77	91	82*
T_4	82	52 ^b	77
T_5	86	19 ^b	74

* Overlapping branches were removed prior to

^b Treatments modified by thinning as described in materials and methods.

Difference between net photosynthesis (A) among the treatments were significant with higher values in T_1 and T_2 (Table III). As a consequence of thinning, A increased substantially in T_4 and T_5 , but later declined (9th year), as the canopy size again increased. These changes followed the variations in PFD (Table I). Transpiration rate (E) also showed similar significant responses in relation to the plant densities. Intercellular CO_2 was lower in T_1 and T_2 as compared to other treatments (Table III). The relation of A and C_i has been reported to be linear in other crops (Balasimha, *et al.* 1991; Farquhar and Sharkey, 1982; Marco *et al.*, 1988). Further, the A/C_i ratio was higher in T_1 and T_2 (Table IV). The ratio of A and C_i represents the 'carboxylation efficiency' (Farquhar and Sharkey, 1982) and higher levels were recorded at higher incident PFD. The increase A/g ratio lead to an increase in intrinsic water use efficiency (A/E).

Table III. Changes in net Photosynthesis (A) and other parameters in cashew

Parameter	Year after Planting	Treatment				
		T ₁	T ₂	T ₃	T ₄	T ₅
A ($\mu\text{mol m}^{-2}\text{s}^{-1}$)	7th	11.87	11.42	8.58	6.11	5.87
	8th	12.07	10.15	6.01	12.11	10.26
	9th	9.23	9.78	6.27	6.50	5.71
L.S.D.	T	=	2.05 **,	Year	=	1.95*
g _s ($\text{mol m}^{-2}\text{s}^{-1}$)	7th	0.39	0.53	0.38	0.38	0.35
	8th	1.14	0.79	0.90	0.84	0.77
	9th	0.54	0.60	0.43	0.76	0.69
L.S.D.	T	=	0.24 NS,	Year	=	0.18**
V _g (cm^3m^{-2})	7th	239	258	216	279	280
	8th	276	266	292	272	276
	9th	264	283	295	297	293
L.S.D.	T	=	14.97*,	Year	=	6.89**
E ($\text{mmol m}^{-2}\text{s}^{-1}$)	7th	9.63	9.70	6.97	6.10	5.27
	8th	15.50	10.85	10.62	11.85	11.22
	9th	13.02	12.72	9.72	12.67	12.02
L.S.D.	T	=	2.35*,	Year	=	1.82**

Significant at p = 0.05 (*) or P = 0.01 (**)

Table IV. Mean values for A/E, A/C_i and A/g_s in cashew

Treatment	A/E	A/C _i	A/g _s
T ₁	0.87	0.043	16.02
T ₂	0.94	0.039	12.32
T ₃	0.76	0.025	12.21
T ₄	0.81	0.029	12.48
T ₅	0.76	0.028	12.13

In cashew competition for irradiance seems to be an important factor and high density cropping system should aim at optimising this limiting factor (Balasimha, 1991; Subbaiah, 1983) Higher yields were obtained in T₄ and T₅ upto 7 years after planting but thereafter declined. This was followed by T₃ upto 7 years after planting but it gave highest yields (468 kg/ha) after this period, which was almost double to what was obtained in T₁. Hedge-rows established at 9 x 3 m accommodating 370 tree/ha gave higher yields in Kenya (Van Eijnatten and Abubaker, 1983). The studies indicate that plant density of 625 trees/ha (4 x 4 m spacing) may be a threshold level for maximising canopy surface area, photosynthetic capacity and yield in cashew on an unit area basis, although the A and irradiances were maximum in T₁ and T₂ on an individual tree basis. However, by 9th year, ground coverage reached maximum in T₃ and it was necessary to maintain the ideal canopy size by pruning the overlapping branches.

ACKNOWLEDGEMENTS

We thank Dr. M.K. Nair, Director, Central Plantation Crops Research Institute, Kasaragod; Dr. E.V.V. Bhaskara Rao, the Scientist in-charge, National Research Centre for Cashew, Puttur for encouragement and permission to undertake these studies; and to Mr C.T. Jose for help in statistical analysis of the data.

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