

Photosynthetic Characteristics of Cashew Trees*

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Abstract

Net photosynthetic rate (P_N) and related characters were measured in field grown *Anacardium occidentale* L. trees. P_N could be measured after eight days of ontogeny and reached maximum levels after completion of leaf expansion. There was no significant difference in P_N at various leaf positions of a single flush. P_N was much lower in the shaded leaves than in the sunlit ones. P_N was linearly related with stomatal conductance and transpiration rate. These results and the high saturation irradiance (1200–1400 $\mu\text{mol m}^{-2} \text{s}^{-1}$) indicated that competition for radiant energy was more important than any other single environmental variable for the cashew photosynthetic capacity. The CO_2 compensation concentration was between 80 and 100 $\text{cm}^3 \text{m}^{-3}$, and the ratio of internal and external CO_2 concentrations, C_i/C_a of 0.80–0.86 indicated the C_3 nature of cashew trees.

Only a few detailed studies of photosynthesis have been carried out on the tropical tree crops like rubber (Samsuddin and Impens 1979), tea (Squire and Callander 1981), coffee (Nunes 1988), and cocoa (Joly and Hahn 1989, Balasimha *et al.* 1991). Cashew (*Anacardium occidentale* L.), a native of the northern part of South America was introduced to India in the 16th century and it has gained economic importance only lately (Bhaskara Rao 1989). In cashew the fruit set and development is dependent on irradiance and the adaptation of leaf to shade is minimum (Subbaiah 1983, 1984). This is the first report on the net photosynthetic rate (P_N) and related parameters in cashew trees.

MATERIAL AND METHODS

The observations were carried out during the 1988-89 and 1989-90 fruiting seasons at the Regional Station (12° 52'N, 75° 42'E and 91 m altitude) in 15-year-old cashew trees (*Anacardium occidentale* L.) which were planted at 8 × 8 m spacing. The trees were raised as rainfed crop (the annual rainfalls during 1988 and 1989 were 3683 and 3678 mm, respectively, distributed mainly from June to October) and no irrigation was given during dry months. The soil was lateritic with a water holding capacity of 30–40 % (0–25 cm), pH range of 5.0–5.7, organic carbon 0.7–1.1 %, total nitrogen 0.05–0.09 %, available P_2O_5 3.8–7.1 g m^{-2} and available K_2O 35–85 g m^{-2} . Fertilizers at the rate of 250 g N, 125 g P_2O_5 , and 125 g K_2O per tree were applied annually.

Leaf area was determined using linear measurements (Murthy *et al.* 1984). It was calculated from the regression equation: $0.21 + 0.69 P$, where P is the product of length and maximum

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breadth. Measurements of irradiance (PAR), temperature of air (T_{air}) and leaf (T_{leaf}), vapour pressure deficit (VPD), P_N , stomatal conductance (g_s) and transpiration rate (E) were made in the leaves using the *LI-6200* portable photosynthesis system with a 1000 cm^3 chamber enclosing up to 20 cm^2 leaf area. Six observations were taken for each tree. Leaf water potential was measured with a Scholander's pressure chamber (*Soil Moisture Equipments Corp., U.S.A.*). All the measurements were made between 10.00 and 12.00 h.

The total soluble sugar content was determined by the phenol-sulphuric acid method with glucose as standard (Dubois *et al.* 1956) in dried leaf material extracted in 80 % ethanol. Chlorophyll was extracted in 85 % acetone, partitioned to remove anthocyanins, suitably diluted and quantified according to Lichtenthaler and Wellburn (1983).

RESULTS AND DISCUSSION

P_N in Relation to Leaf Development

The development of photosynthetic apparatus of cashew is characteristic of some tropical dicots exhibiting leaf flushing rhythms. P_N could be determined after about 8 d of leaf development and reached a maximum at the completion of leaf expansion (Fig. 1). The chlorophyll content increased gradually with leaf expansion

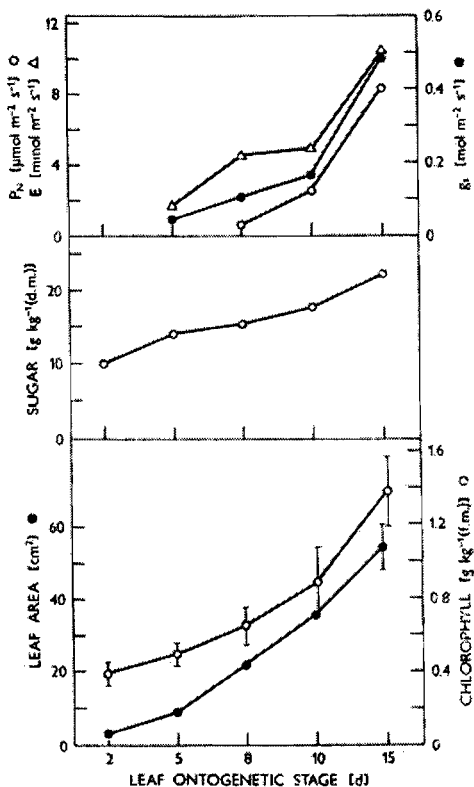


Fig. 1. Photosynthetic characteristics in cashew during leaf development (means of 4 trees with SE where it exceeds the symbols). Microclimate variables were: T_{air} 31.6–37.0 °C; RH 40.0 to 66.7 %; VPD 2.1–5.2 kPa.

sion. g_s and E also showed similar increase and reached maximum levels after full leaf expansion. As a result of these changes the soluble sugar content increased twice after the completed leaf expansion. Similar photosynthetic characteristics have been reported in cocoa (Baker and Hardwick 1975, 1976).

Differences in Leaf Position and Irradiance

The P_N and related parameters were measured in mature leaves of a flush at different positions (Table 1); for a comparison with literature see Šesták (1985). Maximum P_N was found in the first fully mature leaf of the flush. Markedly lower P_N and other characteristics were found in shaded leaves than in sunlit leaves (Table 1). The differences were 22, 28 and 46 % for P_N , g_s and E , respectively. In cashew leaves, studies on specific leaf mass, nitrate reductase and chlorophylls have shown that the adaptation to shade was not maximum (Subbaiah 1984). The reductions in yield in interior trees as compared to border trees are due to lower PAR incidence (Subbaiah 1983). The competition for radiant energy in cashew is more important than competition for soil moisture.

Table 1
Net photosynthetic rate and related parameters of cashew in relation to leaf position from top and irradiance (means of 7 trees). Microclimate variables were: T_{air} 35.6–36.1 °C; RH 41.9–43.3 %; VPD 3.1–3.4 kPa.

Parameter	Leaf position				Standard error	Irradiance		Standard error
	1	3	5	8		sun	shade	
PAR [$\mu\text{mol m}^{-2} \text{s}^{-1}$]	1276	1835	1229	1215	61.7	1388	95	88.4
P_N [$\mu\text{mol m}^{-2} \text{s}^{-1}$]	7.39	6.75	5.99	6.96	0.41	8.14	1.81	0.56
g_s [$\text{mol m}^{-2} \text{s}^{-1}$]	0.50	0.47	0.48	0.46	0.05	0.49	0.14	0.04
CO ₂ intercellular [$\text{cm}^3 \text{m}^{-3}$]	262	265	266	272	4.06	257	275	3.68
E [$\text{mmol m}^{-2} \text{s}^{-1}$]	10.79	10.42	12.27	11.17	0.63	11.53	4.03	0.79
Water potential [MPa]	-0.23	-0.26	-0.27	-0.29	-0.02	-0.30	-0.18	-0.02
T_{leaf} [°C]	34.45	34.46	34.85	35.37	0.40	36.19	31.25	0.46

Relationship with VPD, PAR and Intercellular CO₂

In cashew at full irradiance P_N was not substantially affected by VPD in the range of 2–4 kPa (Fig. 2). Maximum P_N was found between 3.1–3.5 kPa. The high P_N in cashew even at high VPD (> 2.5 kPa) as compared to several other crops like cocoa (Balasimha *et al.* 1991), tea (Squire and Callander 1981) and *Abies alba* (Guehl and Aussenac 1987) only depicts the hardiness and adaptability of the plant to adverse water stress conditions.

Radiant energy saturation of P_N occurred at PAR of 1200–1400 $\mu\text{mol m}^{-2} \text{s}^{-1}$ (Fig. 2). This high saturation level confirms the lack of adaptation to low irradiance (Table 1, Subbaiah 1984). The CO₂ compensation concentration was at about 80–100 $\text{cm}^3 \text{m}^{-3}$ (Fig. 2). The intercellular ambient ratio of CO₂ was 0.80–0.86,

value characteristic of a C_3 plant. This ratio remained constant (despite the irradiance difference) due to the linear relations of P_N with g_s and E (Fig. 3). E had similarly a significant linear relationship with g_s in cashew leaves (Fig. 3).

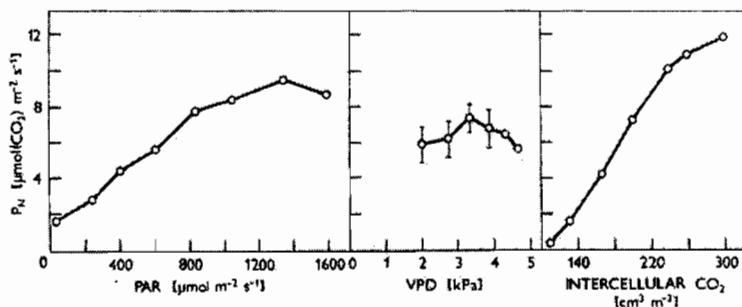


Fig. 2. Relationship between P_N and PAR, VPD and intercellular CO_2 of mature sunlit leaves. Standard errors shown as vertical bars when they exceed the symbols. Microclimate variables were the same as shown in Table 1.

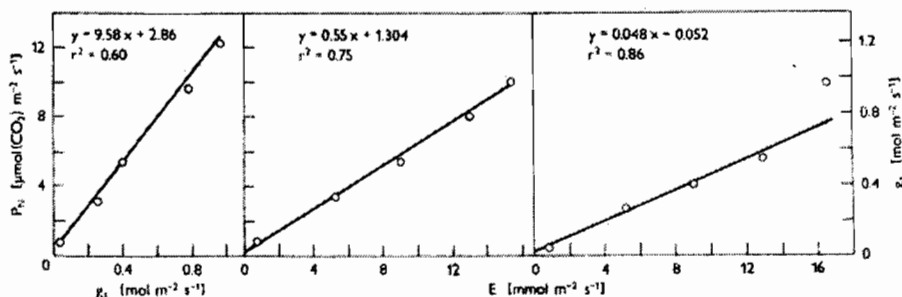


Fig. 3. Relationships of P_N , g_s and E . Mature sun leaves at all positions were taken for the analysis. Microclimate variables were the same as shown in Table 1. $P = 0.01$.

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