COMPARATIVE PHYSIOLOGY OF SUN AND SHADE LEAVES OF CASHEW*

C. CHENCHU SUBBAIAH
Central Plantation Crops Research Institute, Regional Station, Vittal

ABSTRACT

Leaves well exposed to sunlight showed greater specific leaf weight (SLW), nitrate reductase activity (NRA), and content of total phenols than shaded leaves in cashew (*Anacardium occidentale* L.) Though the shade leaves had more chlorophyll with a lower chlorophyll a/b ratio which might compensate for the limiting sunlight, the adaptation was not maximal as their surface areas were similar to those of sun leaves.

INTRODUCTION

Many aspects of tree growth and productivity are influenced by light intensity (Jackson 1975; Diedda *et al.* 1981). A previous report has shown that in cashew, fruit-set and development in a panicle or a whole tree are dependent on the degree of their exposure to photosynthetically active radiation (Subbaiah, 1982b). The present study concerns the morphological and physiological responses of leaves to limiting light intensity since it is the ability of the photosynthetic machinery to adapt to varying light regimes that determine the tree growth and yield.

MATERIALS AND METHODS

Samples were collected from 9 year old cashew trees grown in the experimental plots of our Station. The experimental site and cultural conditions were as described previously (Subbaiah, 1982b).

Fully expanded leaves were collected from:

(*a*) Well exposed canopy zones of border trees

(*b*) heavily shaded portions of border trees, and

(*c*) from the interior trees that were generally shaded.

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Photosynthetically active radiation (PAR) was recorded on all the sampling sites using a Li-Cor quantum radiometer.

Leaf areas were computed by substituting the values of linear measurements in a regression equation (Murthy *et al.* 1978). After recording the fresh weights, leaves were oven dried at 60°C for dry weight determination.

Nitrate reductase activity was assayed by the *in vivo* method (Jaworski, 1971) with a few modifications in the assay medium (Subbaiah, 1982a). Chlorophylls were extracted in acetone and determined spectrophotometrically (AOAC, 1975). Phenolic content was assayed using Folin-ciocaliteau reagent (Farkas & Kiraly. 1962). All the parameters were expressed per gfr. wt. per leaf and per dm^2 leaf area.

All the determinations were repeated with sun and shade leaves from seedlings grown in the open field and under artificial shade.

Results and Discussion

The light intensities (PAR), growth characteristics, chlorophyll and phenolic contents, and NRA, of the three sampling sites are given in Table 1.

The shade leaves were thinner with lower specific leaf weights. This reflects the limited photosynthetic activity of these leaves because specific leaf weight was shown to correlate with the rate of photosynthesis in the leaves of many annual and perennial crops (Dornhoff & Shibles, 1976; Barden, 1978) including cashew seedlings (Subbaiah & Aggarwal, unpublished). However, because of the lesser mechanical tissue per unit leaf area (as reflected by their smaller specific leaf weights) the respiratory losses also would be minimal in the shaded leaves. However, as the absolute leaf area did not differ in the two types of leaves, the leaf acclimatization to shade appears to be partial in cashew

As well documented in the literature, the shade leaves showed higher chlorophyll content per unit weight in cashew too However, the amount of chlorophyll per unit area of leaf surface was

lower than that of the sun leaves, in the case of border trees. This might be because of the fewer chloroplasts per unit area of lamina. But in the case of interior trees, the leaf pigment content was always higher either on the weight or area basis than that of the sun leaves and thus they might be more efficient in tapping light. The ratio of chlorophyll a/b was lower in the shade leaves. This facilitates greater absorption in the green wave length and thus has an adaptive advantage, in view of the availability of filtered light rich in green region, to the shade leaves.

Table 1. PAR, growth characteristics, chlorophyll and polyphenolic contents and NRA of sun and shade leaves cashew.

Character	Leaf type/sampling site			C.D.
	Border Trees		Interior Trees	
	Sun Leaves	Shade Leaves		(P=0.05)
1. (PAR) (μ-insteins/ cm^2/sec)				
at 10 AM	1100	80	150	—
at 3 PM	1140	150	175	—
2. Growth characteristics				
SLW (mg/cm^2) Fresh wt.	29.70	22.13	21.14	1.65
,, Dry wt.	13.10	8.58	8.67	0.89
Area (cm^2)	55.91	60.64	51.75	NS
water content (% dry wt.)	132.20	155.76	157.76	10.40
3. Chlorophyll content:				
a + b mg/g/fresh wt.	0.58	0.69	0.86	0.21
,, mg/leaf	0.93	0.83	0.98	NS
,, mg/dm^2	1.72	1.38	1.88	NS
a/b ratio	3.32	2.91	3.05	0.21
4. Phenolic contents $(mg)^{-1}$				
g/fresh wt.	17.59	14.89	—	NS
$leaf^{-1}$	26.12	18.22	—	4.5
dm^{-2}	49.49	30.74	—	9.39
5. NRA (μ moles NO_2)	**Border trees**			
g^{-1} fresh wt.	0.43	0.39		NS
$leef^{-1}$	0.77	0.56		NS
cm^{-2}	1.22	0.88		NS

The activity of nitrate reductase (NR), a key enzyme in plant nitrogen metabolism was also lower in the shade leaves. The role

of light in the induction and maintenance of NR is well-known (Beevers & Hageman, 1972). Besides, the reductive potential necessary for this enzyme activity might also be limiting because of the low light intensity.

Thus, shade leaves in their adaptation for economical use of available sunlight had to invest a greater portion of their synthetic capacity in the synthesis and maintenance of the light harvesting system, as reflected by the enhanced chlorophyll content, but had to sacrifice the levels of essential enzymes like NR. Even this type of acclimatization to low light intensity appears to be limited in cashew as exemplified by the low leaf areas. Besides, in many instances, severe shading was found to result in self-pruning in cashew (unpublished). Such a poor adaptability to shade in this crop was found to influence its fruiting and yield also (Subbaiah, 1982b).

The total phenolic content was also found to be lower in the shade leaves. Light is known to promote the biosynthesis of phenols in plants (Engelsma & Meijer, 1965). The thin shade leaves with their low phenolic content might render themselves susceptible to pests. In fact, the fruit loss due to tea mosquito damage in cashew was found to be more in the shaded zones of the canopy (Subbaiah 1982b).

Thus, these studies clearly point out that cashew has an obligate need for high light intensity and shows only limited capacity for shade adaptation. However, detailed and systematic shading experiments are necessary to quantify the optimum light requirement for growth and productivity of cashew trees.

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DISCUSSION

N. VASUDEVA (CCRI, Chikmagalur): What type of shade was used for studying NR activity?

C. CHENCHU SUBBAIAH: Only the natural shade available within the tree and in the plantation, was considered.

M. LAKSHMANAN (Madurai Kamaraj Univ., Madurai): You made a statement that the shaded leaves with higher chlorophyll content compensate for the less light availability. Is this true? Is there a correlation between chlorophyll content and photosynthetic activity beyond a certain concentration? An in vitro experiment if done at the concentration of chlorophyll and light intensity available in the leaf would confirm/contradict your assumption.

C. CHENCHU SUBBAIAH: Higher chlorophyll means better light harvesting system under shade conditions. I do not hold the view that chlorophyll has a direct correlation with photosynthetic rate. Higher chlorophyll helps in better trapping of light only.