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LEAF ANATOMY OF FIVE MEDICINAL SPECIES GROWN UNDER TWO LIGHT REGIMES[1]

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Abstract

The foliar anatomy of five species of medicinal plants viz., *Adhatoda beddomei*, *A. vasica*, *Alpinia galanga*, *Plumbago rosea* and *Strobilanthes heyneanus*, grown as intercrops in rubber plantations under direct sunlight and 70% shade was studied. A significant decrease in leaf thickness was observed under shade which could be attributed to a decrease in intercellular space and cell number in palisade layer.

Keywords : Intercrops, rubber plantation, shade

Abbreviations : FAA - formalin-acetic acid-alcohol

Introduction

There has been a fresh global interest in medicinal plants due to their pharmaceutical potential. Majority of these plants flourish under the shade of dense canopy of tropical rain forest trees. Study has been initiated at RRII on a number of medicinal plants to study the feasibility of growing them under rubber trees (*Hevea brasiliensis*) as intercrops. Five commercially important medicinal species were selected. This paper is a comparative study of leaf anatomy of these five medicinal species grown under two light conditions.

Materials and Methods

The five species studied are *Adhatoda beddomei* C.B. Clarke, *A. vasica* Nees, *Alpinia galanga* Sw., *Plumbago rosea* L. and *Strobilanthes heyneanus* Nees. Three-month-old plants grown in pots were subjected to two light conditions, sunlight and 70% shade provided by polyethylene netting. For each treatment 4 leaves were studied. Morphological, anatomical and physiological observations were recorded 16 months after treatment. Leaf samples fixed in FAA were processed for serial microtome sections (8-10 μm) and stained with safranin O-fastgreen FCF for general histology.

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Observations

Leaves of *Adhatoda beddomei*, *A. vasica*, *Plumbago rosea* and *Strobilanthes heyneanus* are dorsiventral, and those of *Alpinia galanga* are isobilateral. The general leaf anatomy and the effect of shade on the anatomical features in all the species under direct sunlight and 70% shade are described. Table 1 gives a quantitative data on constitutive thickness of epidermis, the palisade and the spongy tissues in leaves of the five species grown under the two light conditions.

ADHATODA BEDDOMEI — Leaves grown under direct light had 3- or 4-layered compactly arranged palisade (Fig. 1A), whereas in shade leaves only 2 or 3 palisade layers could be observed (Fig. 1B). Intercellular spaces in the spongy mesophyll were also decreased under shade. However, the percent of total leaf thickness occupied by the palisade zone in both direct light and shade leaves was 42. Similarly the spongy layer occupied 38% and 37% respectively under direct light and shade.

ADHATODA VASICA — Plants grown in direct light showed 2 or 3 layers of compactly arranged palisade cells and loosely arranged spongy cells (Fig. 1C). The vascular bundles had sclerenchymatous bundle sheath extensions. The shade leaves also had 2 or 3 palisade layers (Fig. 1D), but the cell size was small. The palisade parenchyma occupied 44% and 45% of the total leaf thickness in shade and direct light respectively; the spongy mesophyll cells constituted 33% and 46% respectively in the shade- and light-grown plants.

TABLE 1 — EXTENT OF LEAF TISSUES IN PLANTS GROWN UNDER DIFFERENT LIGHT TREATMENTS

Species	Light Treatment	Thickness (μm)			
		Epidermis	Palisade Parenchyma	Spongy Mesophyll	Total
Adhatoda beddomei	Direct sunlight	50	105*	95*	250*
	70% shade	45	90	80	215
Adhatoda vasica	Direct sunlight	25*	100	105*	230*
	70% shade	45	95	70	210
Alpinia galanga	Direct sunlight	95	65*	70*	230
	70% shade	110	40	85	235
Plumbago rosea	Direct sunlight	35*	105*	155*	295*
	70% shade	55	60	85	200
Strobilanthes heyneanus	Direct sunlight	55	105*	65	225*
	70% shade	45	70	60	175

† The values are averages of 16 determinations
* Significant at 5% level

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Fig. 1A-K — Transections of leaves grown in direct sunlight (A,C,E,G and J) and in 70% shade (B,D,F, H and K). A,B. *Adhatoda beddomei*. C,D. *A. vasica*. E,F. *Alpinia galanga*. G,H. *Plumbago rosea*. J,K. *Strobilanthes heyneanus*. A-K x 125.

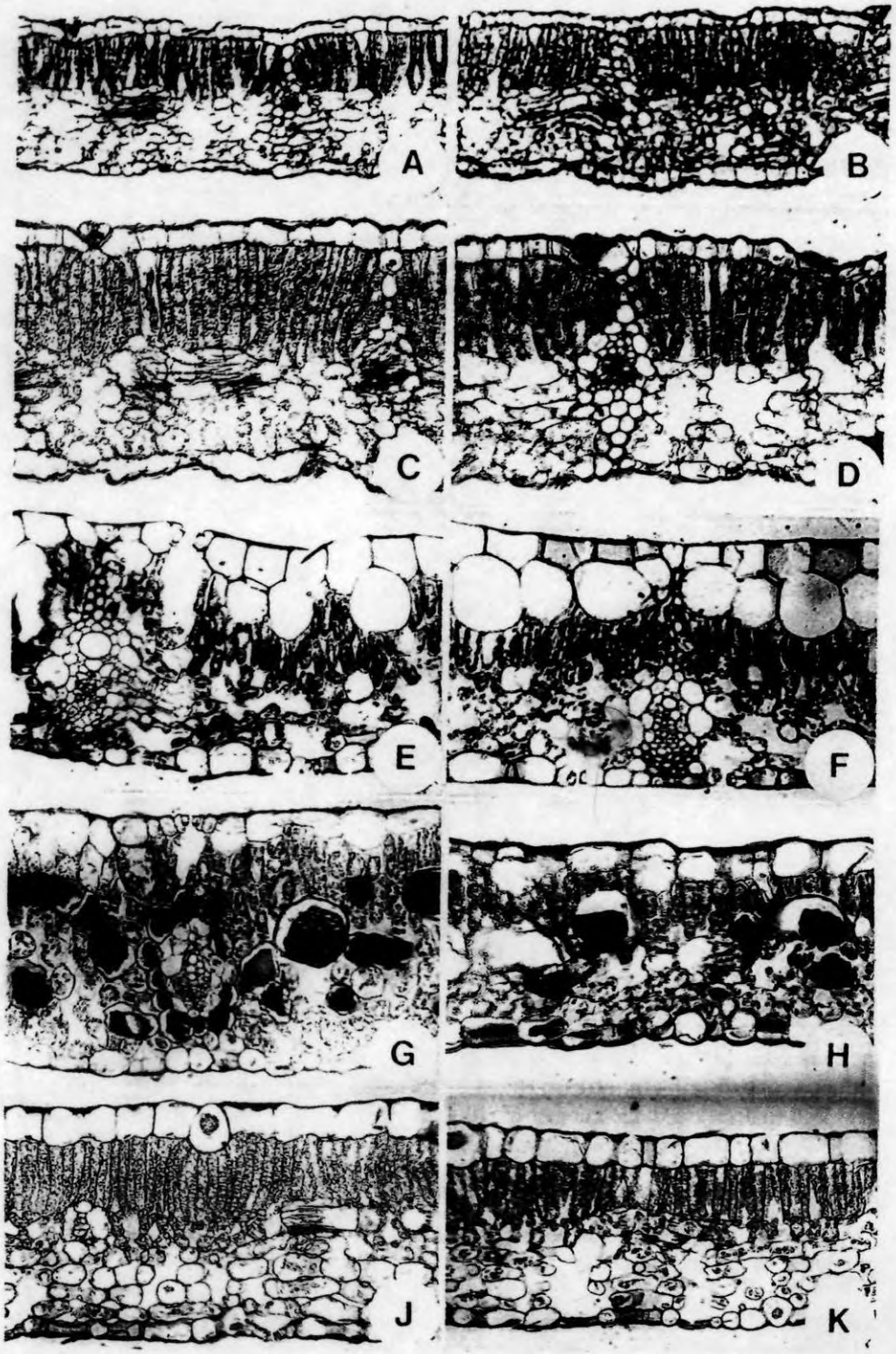

Fig. 1A-K

ALPINIA GALANGA — In plants grown under full sunlight the adaxial leaf epidermis was 1-layered except at some regions where it was 2-layered (Fig. 1E). In shade leaves, the upper epidermis was consistently 2-layered (Fig. 1F). The cells in the outer layer were rectangular, and in the inner layer polygonal or oval. The large-sized epidermal cells contributed to the bulk of the total leaf thickness occupying 41% and 47% respectively in the two types of plants, whereas the palisade zone occupied 28% and 17% respectively. The palisade was 1- or 2-layered with abundant chloroplasts. The bundle sheath extension was more pronounced in plants grown under direct sunlight than that in plants under shade.

PLUMBAGO ROSEA — In plants grown under full sunlight two layers of compactly arranged palisade cells were observed; the outer layer was more or less uniform (Fig. 1G). The spongy zone was 4- to 7-layered. The chlorophyll pigmentation was more intense in the palisade zone. Many cells of the ground tissue possess tannin-like substance bundles (Fig. 1G). The vascular bundles are conjoint, collateral and ensheathed by a parenchymatous sheath. In shade leaves the palisade zone is 1-layered; however, in some region an additional layer of small cells was present (Fig. 1H). Spongy mesophyll layer showed decreased thickness, and the extent of intercellular spaces was also less. In plants grown under direct sunlight the palisade constituted 35.6% and the spongy layer 25% of the leaf thickness; the corresponding values for the plants in shade are 30.8% and 43.3%.

STROBILANTHES HEYNEANUS — A distinguishing feature of the shade plants of this species was the appearance of wavy cell margins in the epidermis, in addition to the presence of a 1-layered palisade except at places where an additional layer of small cells was found (Fig. 1K), and fewer cells in the spongy mesophyll. The palisade parenchyma alone contributed to 40%, and the spongy mesophyll to 34% of the leaf thickness.

Contrastingly in plants which received direct sunlight the epidermal cells were polygonal and the palisade was uniformly 2-layered (Fig. 1J). The thickness of the palisade and the spongy mesophyll were respectively 47% and 29%.

Discussion

Plants grown under direct sunlight and shade condition are reported to show morphological and anatomical variations (Kramer & Kozlowski 1979). Generally the leaves of shade plants are thin and this is evident from the data of species grown under different shade conditions (Boardman 1977, Abrams 1987, Adams et al. 1987, Regnier et al. 1988, Messier et al. 1989, Abrams & Kubiske 1990, Fahl et al. 1994, Marler et al. 1994, Shiraishi et al. 1996, Utsunomiya & Higuchi 1996). In our study we observed that the leaf thickness in all the five species grown in shade was decreased as compared to that in the plants grown in direct sunlight. This was either due to a decrease in the number or size of the leaf tissues. Besides quantitative differences in the extent of the different tissues in the leaf, qualitative variations in mesophyll cell size, and the extent of air cavities were also observed.

Shade lead to decrease in the number of palisade layers. A decrease in cell number also occurred under shade. Thicker leaves in plants grown at high irradiance have been attributed primarily to increase in the thickness of the palisade layer (Nobel 1976, Patterson et al. 1977a,b, Chabot et al. 1979, Fails et al. 1982, Huang & Kuo 1996). Decrease in spongy cell number in shade plants was also noted. Thicker leaves in sun plants than those in shaded plants, attributable to increased size of the palisade and spongy parenchyma tissues, have been earlier reported (Fahl et al. 1994, Huang & Kuo 1996).

Patterson et al. (1978) suggested that the greater mesophyll thickness in plants receiving high irradiance may lead to shading of chloroplasts by one another within the leaf, causing photosynthesis to

become saturated at higher light intensities. From the present study, it is evident that plants grown in 70% shade showed maximal anatomical adaptation to shade condition.

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