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Modified Sunlight Affects Growth and Flowering of *Saintpaulia ionantha* H. and *Peperomia grisco-argenta* Yuncker

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Abstract. **Tissue culture plantlets of *Saintpaulia ionantha* and *Peperomia grisco-argenta* were grown for 120 days in growth boxes placed in a greenhouse. The filter-covered tops of the boxes were sloped facing south, the direction of the sun, while the walls were constructed of white styrofoam board Four types of light filters covered the frames. Two blue celluloid sheets were used to alter the sunlight spectrum: one filtered out the red (B + FR), and the other removed most of the red and far-red, FR (B - FR). Two polyethylene films were formulated as light filters and diffusers: one scattered all the transmitted light and decreased the R : FR ratio (W), while the other was neutral in respect to the sunlight spectrum and did not cause light scattering (A). Vegetative growth of *Saintpaulia* plants was enhanced under the light-diffusing filters, resulting in higher fresh weight and larger leaves. *Saintpaulia* plants flowered first under the W filter, then the A filter, and last under the B + FR filter; no flowering occurred in the absence of FR light (B - RR). There was no significant difference in the development of *Peperomia* plants grown under the different filters. The results are discussed in relation to plant adaptation to various environments.**

Many plants used for indoor decoration originated from the substratum of tropical and subtropical forests or the edges of such areas. The spectral composition of sunlight reaching the ground under vegetation is changed by its passage through green leaves or its reflection from leaves (Holmes, 1981). Blue and red wavebands are depleted more than far-red and green. The reaction of plants to these changes is probably affected by phytochrome, through changes in the ratio of Pfr (the FR-absorbing form of phytochrome) to Pr (the red-absorbing form of phytochrome) (Smith, 1986). Plants of open habitats usually react to a reduced Pfr : Pr ratio by increased stem length, decreased leaf area, and reduced branching, interalia (Smith, 1986). Shade-adapted species do not necessarily react in the same manner (Grime, 1981). Shade-tolerant plants such as *Begonia foliosa* HBK, *Chlorophytum comosum* (Thunb.) Jacques, *Pilea cadierei* Gagnep & Guillaum, and *Saintpaulia ionantha,* when grown under a combination of incandescent and fluorescent lamps having a high FR : R ratio, did not elongate as did the plants of open habitats (Cathey et al., 1978). Kadman-Zahavi and Ephrat (1976) tested the effect of various light filters on plants' growth habits; most of the plants tested were greatly elongated in light from which the red part of the spectrum was filtered out (low R : FR), whereas *Pharbitis nil* Choisy, which is native to the Himalayan forests (Imamura et al., 1966), retained very short internodes. Flowering was also greatly affected by the modification of the sunlight spectrum: all long-day plants and many short-day plants flowered earliest in the low R : FR ratio, but some short-day plants such as *Dendranthema ×grandiflorum* (Ramat) Kitamura, *Fragaria ×ananassa* Duch., and *Pharbitis nil* flowered later (Kadman-Zahavi and Ephrat, 1974).

In addition to the canopy's effect on the light spectral distribution, it has a pronounced effect on the angle of light incidence. Shade plants originated under conditions in which most of the light reaching them is diffused and only a relatively small fraction is not scattered.

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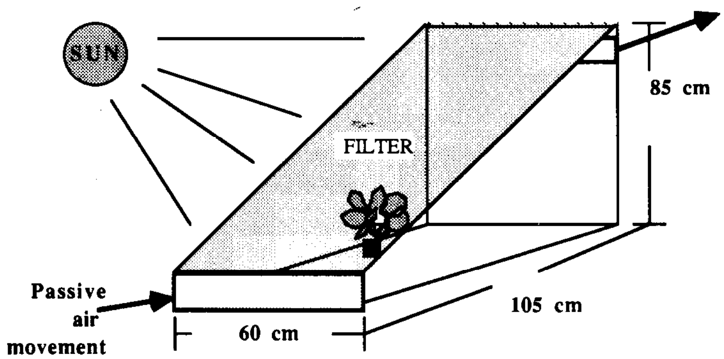

Fig. 1. The experimental growth box.

Table 1. Chlorophyll content of *Saintpaulia* leaf disks.

Filter	Chlorophyll ($\mu g \cdot cm^{-2}$) a	b	Total	Chlorophyll a : b ratio
B+	49.5 b[z]	21.8 b	71.3 b	2.3 c
B−	54.9 b	18.7 c	73.5 b	3.0 a
W	70.9 a	27.2 a	98.1 a	2.6 b
A	74.3 a	28.9 a	103.2 a	2.6 b

[z]Mean separation in columns by Duncan's multiple range test (P = 0.01).

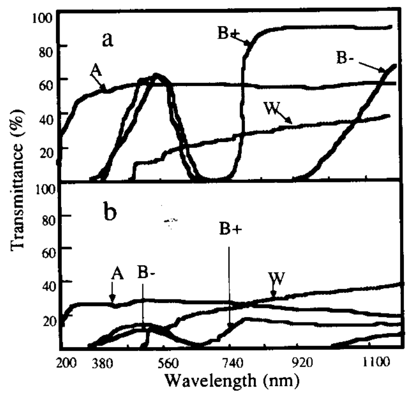

Fig. 2. Spectral transmittance (%), global **(a),** and diffused **(b)** light of the four experimental filters.

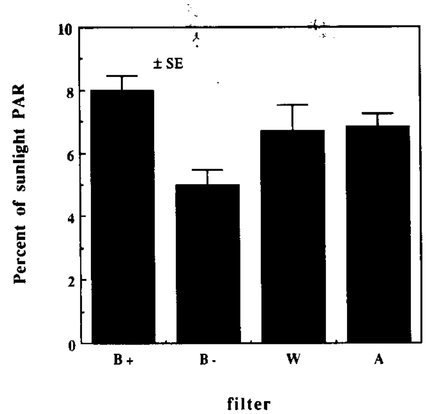

Fig. 3. Transmission of PAR within the growth boxes as percentage of sunlight PAR.

Until recently, most greenhouse cladding and shading materials were neutral in respect to light quality. The introduction of "fluid roof" systems using colored liquids (Chiapale et al., 1976; Van Bavel and Damagnez, 1978) and other types of spectrally modified cladding materials (Raviv, 1989) made light quality control a viable option as demonstrated by Mortensen and Stromme (1987). The aim of the present work was to study the responses of *S. ionantha* and *P. grisco-argenta* as representatives of flowering and foliage tropical house plants to changes in the sunlight spectrum and diffusion.

In vitro-grown *S. ionantha* and *P. grisco-argenta* plantlets were transferred to 200-ml pots containing a-l peat : 1 shredded polyethylene foam (v/v) medium with 5 g Osmocote/liter (14:6.1:11.6). Capillary irrigation was supplied once every 3 days. Plants were grown in growth boxes (Fig. 1) situated on the southern bench of a greenhouse. The greenhouse roof was covered with fiberglass and the walls with clear polyethylene. Photosynthetically active radiation (PAR) transmission was 30% above the boxes. The growth box was a chamber with a 60 × 105 cm base and a top consisting of a filter-covered frame mounted at a 45° angle facing south. Maximum height of the growth box was 85 cm and minimum height 15 cm. The side walls were constructed of white styrofoam boards. Openings at the front and at the top of the back wall enabled free ventilation of warm air. All the boxes were placed at random in one row at the south end of the greenhouse. Two boxes were used with each filter, and 25 plants of each species were grown in each box for 4.5 months. Leaf temperatures were measured with thermocouples and fluctuated between 25 and 35C during the daytime. Four filters were examined (Fig. 2). Two blue celluloid filters were used to alter the sunlight spectrum. B + FR (blue transparent celluloid no. 1460, Celluloid Fabrik Speyer, Germany) filtered most of the red part of the spectrum (600-700 nm) and transmitted blue (400-500 nm) and FR (700-800 nm). B - FR (celluloid no. 1654, Mazzuchelli, Castiglione olona, Varese, Italy) filtered out most of the red and the FR and transmitted only blue light. Two specially formulated polyethylene filters were used to study the effect of light scattering: a white (W) sheet with increased transmittance toward the FR end of the spectrum, and an aluminized sheet (A), providing almost equal transmittance. throughout the visible spectrum. The W sheet scattered all the transmitted light, while the A sheet transmitted 30% direct light. Light spectral transmittance and diffusion were determined using a Gary 2300 spectrophotometer (Cary, Varian Co., Australia) equipped with a diffuse reflectance accessory. Red to far red transmissivity ratios were 0.69, 0, 0.85, and 1.03 for the B + FR, B - FR, W, and A film, respectively.

Transmission of the different filters in the PAR range (micromoles per square meter per sec) were measured. on several occasions with a LI-COR Li-185A quantum meter (LI-COR, Lincoln, Neb.). The PAR was virtually the same for three of the tested filters, while the B - FR filter transmitted less PAR (Fig. 3).

Peperomia fresh and dry weights and number of leaves were recorded at the termination of the test. At the same time, the number of leaves, leaf area, and plant fresh weigh of *Saintpaulia* were recorded. Flowering buds and open flowers in *Saintpaulia* were observed throughout the experiment. Each plant constitutes a replicate analyzed as one-way analysis of variance, followed by Duncan's multiple range test. Chlorophyll was extracted from *Saintpaulia* with *N,N*-dimethylformamide (DMF) (Moran and Porat, 1980). Ten plants were sampled from each treatment. Ten disks (6 mm in diameter) were taken from a young fully expanded leaf of each plant and extracted overnight at 4C in 10 ml of DMF. Optical density of the solution was measured at 645 and 665 nm using a Gilford 250 spectrophotometer (Gilford Instrument, Oberlin, Ohio).

The various filters had no visual effects on the *Peperomia* plants, as evidenced by the lack of significant difference in number of leaves (28-35), fresh weight (18-23 g), or dry weight (0.9-1.2 g).

Saintpaulia plants gained the highest fresh weight under the two light-scattering filters, A and W (Fig. 4C). The difference in fresh weight was almost exclusively a result of a difference in leaf area (Fig. 4B) while leaf count was not affected by the filters (Fig. 4A). Plants grown under the B - FR filter produced a larger leaf area and consequently accumulated more fresh weight than those grown under B + FR, in spite of the greater PAR transmissivity of this filter. Chlorophyll content (Table 1) was higher in the plants growing under the light-scattering filters (A and W) than in those under the two blue filters.

The flowering of the *Saintpaulia* plants was strongly affected by the spectrum (Fig. 5). The first plants to flower were those under the W filter, followed by those under the A filter, and finally the B + FR filter; plants did not initiate flower buds under the B - FR filter.

Scattered light was more efficient than direct light for growing *Saintpaulia* in terms

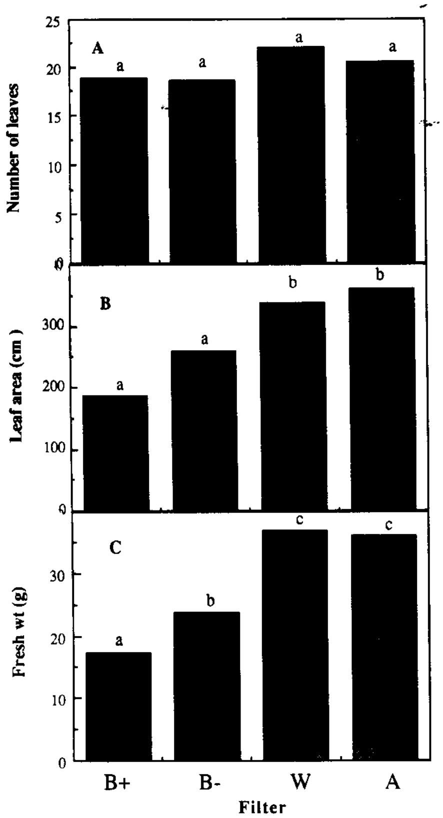

Fig. 4. The effect of light filters on the number of leaves **(A),** total leaf area **(B),** and leaf fresh weight **(C)** of *Saintpaulia* plants. Means separation within treatment by Duncan's multiple range test at $P = 0.05$.

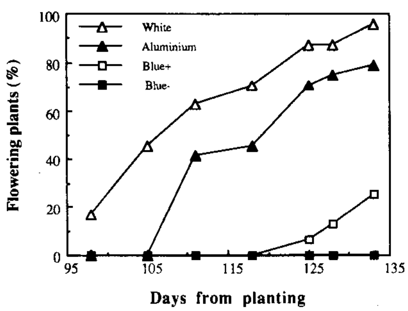

Fig. 5. The timing of flower appearance in *Saintpaulia* plants grown under various light filters.

of leaf area and fresh weight. *Saintpaulia* flowering was greatly affected by the changes in the spectrum, being prevented entirely in the low-FR environment (B - FR). The enhancement of flowering under the white filter can probably be ascribed to the relative increase in FR under the W filter as compared with the A filter. Extensive scattering of FR by the W filter (Fig. 2) probably ensured its pronounced effect on canopy-covered buds as compared with the B+filter, which transmitted mainly direct FR wavebands. The *Saintpaulia* plant can serve as a good example of adaptation to under-canopy conditions. Modification of the sunlight spectrum in environment where shading is required can be accomplished by the use of photoselective cladding materials so as to increase the efficiency of pot plant production, as demonstrated by enhanced flowering of the *Saintpauliu* plants under high FR : R ratio.

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