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Effect of light on senescence of cut leaves of *Zantedeschia aethiopica* Spr. and *Hosta* Tratt. 'Undulata Erromena'

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ABSTRACT

The effect of white, red, and blue lights on postharvest longevity, chlorophyll content and stomatal aperture in cut leaves of *Zantedeschia aethiopica* Spr. and *Hosta* Tratt. 'Undulata Erromena' was studied. Red light doubled leaf vase life in *Zantedeschia*, delayed chlorophyll degradation, and decreased the stomata aperture. Blue light prolonged leaf longevity in *Hosta* delaying chlorophyll loss but without affecting stomata.

INTRODUCTION

Senescence is a highly organized process involving structural, biochemical, and molecular changes leading to gradual cell degradation and death of an organ or an organism. In detached leaves they are accelerated by stress conditions due mainly

to the detach organs from a mother plant, which leads to disturbed water balance. Water uptake by cut leaves is related to transpiration and depends on light, which – according to its intensity and quality – can accelerate or delay leaf senescence (Behera and Biswal 1990). Light affects chlorophyll degradation in detached leaves (Behera and Biswal 1990) and controls stomatal aperture (Frechilla et al. 2000). Stomatal opening is caused both by the red and blue part of the photosynthetically active irradiance. Irradiance quality can affect osmoticum controlling turgor pressure of stomata (Maleszewski and Kozłowska-Szerenos 1998).

Zantedeschia and *Hosta* are plants of commercial importance providing the florists' green used in cut flower arrangements, therefore it is important to study senescence in their cut leaves in order to effectively delay it at every step of the market chain between the grower and consumer. The present work shows the results of the authors' studies on the effect of light quality on senescence, chlorophyll degradation, and stomatal aperture in cut leaves of the above plants.

MATERIAL AND METHODS

Detached leaves of *Zantedeschia aethiopica* Spr. and *Hosta* Tratt. 'Undulata Erromena' harvested from plants grown in the didactic collections of the Department of Ornamental Plants were used in the experiments. Mature leaves were harvested in the morning and immediately transported to the laboratory. Leaf petioles were trimmed to 15 cm and placed into vases (5 leaves per vase) with distilled water (500 cm^3). Ten leaves were used in each longevity test and the averages of three experiments are given in the tables. Leaf vase life was considered as terminated when 30% of a leaf surface showed signs of yellowing.

Vases were placed under three different lights: white light was provided by fluorescent Philips TLD White 36W/96 lamps (maximum – 440, 490, 550, and 612 nm), red – by Philips TLD Red 36W/15 (max. 660 nm), and blue – by Philips TLD Blue 36W/18 (max. 436 nm). Irradiance intensity, measured by the phytophotometer FF-01, was 12 $\mu mol\ m^{-2}\ s^{-1}$. Light was provided 12 hours in 24 h cycle and the temperature was $21 \pm 1°C$.

Chlorophyll content was determined after extraction with dimethylformamide (DMF) according to Moran and Porath (1980) in modification of Inskeep and Bloom (1985). Chlorophyll was calculated per gram of dry weight and given in mg g^{-1} d.w. Pigment was determined immediately before placing the leaves in the vases and at the end of experiment (at a date specific for a given treatment). Material for analyses was collected from three leaves, pooled together, finely cut, mixed, and then three 1 g samples were weighed for extraction and another 3 for dry weight determinations (drying at 105^oC until sample constant weight). Three absorption readings were made for each extract.

The degree of stomata opening was determined by a modified replica method as described by Poskuta and Karpowiczowa (1971). Stomata aperture was measured under an OLYMPUS IX70 microscope, at 400x enlargement, making 90 readings for each data and using an AnalySis program.

Results were statistically evaluated using ANOVA 1 or ANOVA 2. Means were compared using the Duncan's test at probability level $p = 0.05$.

RESULTS AND DISCUSSION

Literature concerning the effects of light quality on leaf senescence is not abundant. Depending on its quality and intensity, light can both enhance or delay senescence in leaves. Behera and Biswal (1990) showed that both red and blue light delayed senescence in cut leaves of *Nephrolepis exaltata*. According to Merzlyak et al. (1999) only the red light can postpone degradative processes in leaves which was shown in alstroemeria (Van Doorn and Van Lieburg 1993, Jordi et al. 1994, Kappers et al. 1998). In present experiment the response of cut leaves to light quality varied, depending on the plant species. Red light doubled the leaf longevity in *Zantedeschia aethiopica* in comparison with white light (Table 1) while in *Hosta* (Table 2) it was blue light which prolonged the vase life (40% in comparison with white light). Positive effect of either light on leaf longevity was related to a retarded chlorophyll degradation in a given treatment (Tables 1 and 2).

Table 1. Effect of light quality on vase life and chlorophyll content (16 days after harvest) in detached leaves of *Zantedeschia aethiopica*. Chlorophyll content immediately after harvest: 18.5 mg g^{-1} d.w.

Light	Vase life [days]	Chlorophyll content [mg g^{-1} d.w.]
White	19.7 a1	7.7 b
Red	37.7 b	13.1 c
Blue	14.2 a	2.9 a

[1] Means followed by the same letter do not differ significantly at $p = 0.05$ (Duncan's test)

Table 2. Effect of light quality on vase life and chlorophyll content (16 days after harvest) in detached leaves of *Hosta* 'Undulata Erromena'. Chlorophyll content immediately after harvest: 16.2 mg g^{-1} d.w.

Light	Vase life [days]	Chlorophyll content [mg g^{-1} d.w.]
White	11.1 a1	8.3 b
Red	10.0 a	1.9 a
Blue	15.5 b	11.9 c

[1] Explanations as in Table 1

According to Maleszewski and Kozłowska-Szerenos (1998) both the red and blue light component affect stomata aperture, but many authors believe that only blue light stimulates stomata opening (Assmann 1993, Zeiger and Zhu 1998, Frechilla et al. 2000, Lawson et al. 2002). Indeed, in detached leaves of

Zantedeschia aethiopica the largest stomata aperture (8.2 μm) was observed under blue light (Table 3). Under red light – although almost 50% reduction in the aperture was found – stomata remained slightly opened (4.6 μm) during the whole period of the experiment (Table 3). A decrease in stomatal aperture could decrease transpirational losses of water from leaves, allowing, however, air exchange and diffusion of ethylene from internal spaces. Kirk et al. (1986) proved that treatments allowing the stomata to stay open – thus enabling escape of internal ethylene from leaf tissues – prolong the longevity of cuttings in *Hibiscus*. Earlier studies on ethylene biosynthesis by cut leaves (Skutnik 1998) showed that it is negligible so the possibility of C_2H_4 diffusion through either widely open (blue light) or partly closed stomata (red light) might not be a case here. Jordi et al. (1994) showed that in cut alstroemeria red light delayed chlorophyll losses and maintained photosynthetic activity in leaves, which might also occur in *Zantedeschia* and *Hosta*, but photosynthetic activity was not measured in this experiment. It is difficult to speculate on a definite role of light in prolonging the cut leaf vase life in the species under study, especially as a different situation was observed in *Hosta* where blue light delayed leaf senescence without, however, causing the stomata to close. A relationship between light quality, stomatal aperture, and longevity of cut leaves remains unclear and needs further studies.

Table 3. Effect of light quality on stomatal aperture (between 9.30 a.m. and 3.30 p.m.) in detached leaves of *Zantedeschia aethiopica*

Light	Stomatal aperture [μm] after			Mean for light ($LSD_{0.05}$ = 0.322)
	6 hours	6 days	13 days	
White	7.28	5.97	6.86	6.70 b[1]
Red	3.40	4.71	6.49	4.57 a
Blue	9.58	6.93	8.02	8.18 c
Mean for a term ($LSD_{0.05}$ = 0.321)	6.78 b	5.87 a	7.12 c	

[1] Means followed by the same letter do not differ significantly at p = 0.05 (Duncan's test). To compare the means within the Table: $LSD_{0.05}$ = 0.562

Table 4. Effect of light quality on stomatal aperture (between 10.30 a.m. and 4.30 p.m.) in detached leaves of *Hosta* 'Undulata Erromena'

Light	Stomatal aperture [μm] after			Mean for light ($LSD_{0.05}$ = 0.222)
	6 hours	1 day	12 days	
White	4.48	5.56	5.08	5.07 a[1]
Red	4.43	5.72	4.82	4.99 a
Blue	4.81	5.15	4.98	4.98 a
Mean for a term ($LSD_{0.05}$ = 0.221)	4.57 a	5.51 c	4.96 b	

[1] Explanations as in Table 3; to compare the means within the Table: $LSD_{0.05}$ = 0.393

CONCLUSIONS

1. Red light increased the postharvest longevity of cut leaves in *Zantedeschia aethiopica*, delaying chlorophyll losses and limiting stomatal aperture.
2. Blue light delayed senescence in cut leaves of *Hosta* 'Undulata Erromena', retarding chlorophyll degradation but without affecting stomata.

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WPŁYW ŚWIATŁA NA STARZENIE CIĘTYCH LIŚCI *ZANTEDESCHIA AETHIOPICA* SPR. I *HOSTA* TRATT. 'UNDULATA ERROMENA'

Streszczenie: W doświadczeniach analizowano wpływ światła białego, czerwonego i niebieskiego na pozbiorczą trwałość, zawartość chlorofilu i stopień rozwarcia szparek w ciętych liściach cantedeskii etiopskiej i funkii 'Undulata Erromena'. Światło czerwone dwukrotnie przedłużyło okres dekoracyjności ciętych liści cantedeskii etiopskiej, hamując degradację chlorofilu i powodując lekkie przymknięcie aparatów szparkowych. Światło niebieskie przedłużyło pozbiorczą trwałość liści funkii 'Undulata Erromena', ograniczając straty chlorofilu, ale nie zmniejszając stopnia otwarcia szparek.

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