PREVENTION OF PHYTOCHROME-RELATED POSTHARVEST LOSS OF QUALITY IN ORNAMENTALS THROUGH RED LIGHT EMITTED BY DIODES

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#### Abstract

Loss of quality during transport and storage of plants in the dark may be due to short-term phytochrome-related processes. Cut flowers of Alstroemeria pelegrina L. cv. Yellow King held in water and kept in the dark for nine days at 20°C showed leaf yellowing. Red light during this period resulted in higher total chlorophyll content than dark treatment (112 and 72 mg/100 g fresh weight resp.). Far-red light completely nullified the effect of red light.

Hibiscus rosa-sinensis L. cv. Nairobi plants kept in the dark for four days at 20°C lost 74% of all flower buds; this could be reduced to 31% by red light. Far-red light reversed the effect of red light to 91%. Red/far-red reversal was established by a 30/45 sec red/far-red regime and a 30/45 sec red/dark regime, applied continuously during the experiment. Red light emitting diodes (660 nm peak,  $3.3~\mu \text{mol.m}^{-2}.\text{s}^{-1}$  in the 635-685 range) were mounted in filters implemented to produce the far-red fraction from incandescent light. This enabled convenient alternation of the two action spectra in one system.

Heat production is a main obstacle for applying light during transport or storage of ornamentals. Use of light emitting diodes prevents heat build-up. Compared to fluorescent tubes and incandescent lamps, red light emitting diodes are six times more efficient in converting electrical energy to photon flux density in the 635 -685 nm range.

#### 1. Introduction

Transport and storage of ornamentals, mostly occurring in the dark, may lead to considerable loss of quality. In addition to damage due to lack of photosynthesis, short-term phytochrome-related processes may play a role in dark-induced damage. Loss of chlorophyll is one of the symptoms associated with dark storage (Poole and Conover, 1979). It has been established that chlorophyll synthesis is mediated by phytochrome (Raven and Shropshire, 1975) but a role of phytochrome in chlorophyll breakdown has apparently not been

reported. Cut flowering branches of Alstroemeria pelegrina L. cv. Yellow King held in water are known to show rapid chlorophyll breakdown both at low light levels (12 hrs per day, 15  $\mu$ mol.m<sup>-2</sup>.s<sup>-1</sup>, TLD 36W/84) and in the dark (Van Doorn, 1988). We have investigated whether leaf yellowing in this cut flower is mediated by phytochrome.

Abscission of buds is another symptom often observed during dark storage. Bud abscission in lilium has been associated with increased sensitivity to and a subsequent rise in ethylene following dark treatment (Van Meeteren and De Proft, 1982). Ethylene sensitivity of Vigna radiata to ethylene-induced leaf abscission has been reported to be decreased by red and reversed by far-red light (Decoteau and Craker, 1987). Red light also reduced ethylene production in Phaseolus vulgaris (VanGronsveld et al., 1988), Pisum sativum (Goeschl et al., 1967) and Glycine max (Samimy, 1978). These effects on ethylene production were all far-red reversible. We examined the effect of red and far-red light on bud abscission in the pot plant Hibiscus rosa-sinensis L. cv. Nairobi.

# 2. Material and methods

### 2.1. Alstroemeria

Cut flowering branches of Alstroemeria pelegrina L. cv. Yellow king were obtained from a commercial grower. Plants had been grown for ten weeks at daylight conditions at day/night temperatures of 17°C/13°C. Flowering stems were placed in distilled water (three stems per vase) and divided into four batches of three replicates (three stems per replicate) each. These received the following light regimes for nine days at 20°C: red/dark 30/45 sec; red/far-red 30/45 sec; continuous red and continuous dark. The experiment was repeated twice.

The far-red light (730 nm peak, half band width 25 nm) was generated by filtering light from 25 watt incandescent bulbs through a 3 mm plexiglass filter (Röhm & Haas) no. 627 (blue) and a 3 mm filter no. 501 (red). The red light was produced by LEDs, i.e. light emitting diodes (660 nm peak, half band width 25 nm, Nijssen Light Systems, Leiden, The Netherlands) which were mounted in the plexiglass filters. This setup facilitated alternation of the action spectra in one cabinet. A high precision time switch (Schleicher, Microlais-D, Germany) was used to alternate the action spectra. Light measurements were carried out with a LiCor-1800 portable Spectroradiometer at 20 cm from the light source. The red (635-685 nm) photon flux density was 3.3  $\mu$ mol.m<sup>2</sup>.s<sup>1</sup> and the far-red (705-755 nm) photon flux density was 7.5  $\mu$ mol.m<sup>2</sup>.s<sup>1</sup>. Photosynthetic (400-700 nm) fluence was 120  $\mu$ mol.m<sup>-2</sup> per 75 sec in both the 30/45 sec red/dark and the 30/45 sec red/far-red regime. In the continuous red treatment the photosynthetic fluence was 300 μmol.m<sup>-2</sup> per 75 sec. The light treatments were given in light-tight cabinets (0.25 m³) ventilated at a rate of 160 m³.hr 1 to prevent build-up of ethylene and  ${\rm CO_2}$ . After nine days of treatment total chlorophyll content of whole leaves was determined following the procedure of Vernon (1960). Fifteen leaves were taken from three flowering stems for chlorophyll analysis. Results were compared by analysis of variance.

### 2.2. Hibiscus

Hibiscus rosa-sinensis L. cv. Nairobi plants were obtained from rooted cuttings and were grown in a glasshouse for seven months in 14 cm pots containing a mixture of peat and moss litter (2:3) amended with sand and limestone and fertilizer (14 N - 16 P - 18 K + micronutrients). Lights (SON-T,400W) were switched on below 100  $\mu$ mol.m $^2$ .s $^1$  and off above 200  $\mu$ mol.m $^2$ .s $^1$  daylight (7 AM - 11 PM). Day and night temperatures were 20°C and 19°C, respectively. Whole plants were exposed to the same four light treatments as alstroemeria branches for four days at 20°C. Twenty-four plants were placed under each light regime. After ending these treatments bud abscission was recorded for six days at a light intensity of 136  $\mu$ mol.m $^2$ .s $^1$  (SON-T, 400W, 12 hrs.per day) at 20°C without daylight. Abscission was measured in three groups of eight plants and the results were compared by analysis of variance. The experiment was repeated twice.

## 3. Results and Discussion

#### 3.1. Alstroemeria

Total chlorophyll content was higher in the red/dark and in the continuous red treatment than in the dark treatment (Table 1). No significant difference was found between the red and red/dark treatments indicating saturation of the red light effect. The far-red treatment nullified the positive effect of the red treatment. Despite the same photosynthetic fluence in the red/dark and the red/far-red regime the difference in chlorophyll content was significant. This suggests a role of phytochrome in net breakdown of chlorophyl.

## 3.2. Hibiscus

Red light applied continuously reduced bud abscission to the same extent as the red/dark regime did (Table 2). In both cases the difference with the dark control was significant. By applying far-red light after the red light period, the positive effect was reversed and abscission was even higher than in the dark treatment. This suggested involvement of phytochrome. The possibility of discrepancies through different levels of photosynthesis was precluded by applying the same photosynthetic fluence in the red/dark and red/far-red regime during the experiment. This was considered of particular importance as Force et al. (1988) reported more abscission at a photon flux density of 500  $\mu$ mol.m<sup>2</sup>.s<sup>1</sup> than at a photon flux density of 980 µmol.m<sup>2</sup>.s<sup>1</sup>, in Hibiscus rosa-sinensis L. cv. Brilliant Red. Force et al. (1988) also found that removal of mature buds before dark storage reduced abscission of younger buds. In addition to phytochrome, therefore, availability and partitioning of assimilates apparently plays a role in abscission.

## 4. Practical implications

Heat production is a main obstacle for application of conventional light sources during storage and transport in closed containers. LEDs provide an alternative without heat build-up. The light emitting properties of LEDs are not based on thermal radiation as in incandescent lamps but on luminescence as in fluorescent tubes. LEDs emit light at  $25\,^{\circ}\text{C}$  against incandescent lamps at  $700\,^{\circ}\text{900}\,^{\circ}\text{C}$ .

Compared to fluorescent tubes and incandescent lamps red LEDs are more efficient in converting electrical energy to photon flux density in the 635-685 nm range (Table 3). This is particularly relevant in those cases were phytochrome action is involved. LEDs can operate at energy input levels (0.05 watt) far below those needed for conventional light sources.

Other advantages are ruggedness due to encapsulation in resin, their very long life-time and small size.

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Table 1 - Red/far-red reversibility of leaf yellowing in Alstroemeria pelegrina L. cv. Yellow King.

Treatment*	Chlorophyll (mg/100 g fresh weight)
Red/Dark (30/45 sec)	112.4 <sup>a</sup>
Red/Far-red (30/45 sec)	71.8 <sup>b</sup>
Red	117.2 <sup>a</sup>
Dark	71.8 <sup>b</sup>

Means with the same letter are not significantly different at the 5% significance level.

Table 2 - Red/far-red reversibility of bud abscission in Hibiscus rosa-sinensis L. cv Nairobi.

Treatment*	Bud abscission level (%)	
Red/Dark (30/45 sec)	31.1 <sup>a</sup>	
Red/Far-red (30/45 sec)	90.6 <sup>ċ</sup>	
Red	33.2 <sup>a</sup>	
Dark	74.1 <sup>b</sup>	
Means with the same letter are	not significantly different at	

the 5% significance level.

Table 3 - Ratio of photon flux density  $(\mu \text{mol.m}^{-2}.s^{-1})$ , emitted by different light sources, to the energy input (watt).

Range	LED 0.05W	TLD 36W/84	Incandescent 25W
	(red)	(white)	(white)
635-685 nm	0.60	0.10	0.10

<sup>\*</sup> Continuous treatment for a nine-day period.

<sup>\*</sup> Continuous treatment for a four-day period.