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Stargreen: transport simulation of potplants under LED light conditions

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Colophon

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Summary

The effects of application of LED lighting during long-term storage of potted plants were investigated. Plants (Ficus benjamina, Phalaenopsis, Saint Paulia and Dracaena) were stored at 15°C for 20 and 35 days either in the dark or under low light intensities 5μmol/m^2/s and 8μmol/m^2/s (for 16 h a day) provided by LEDs. Dark storage induced leaf abscission in Ficus, flower and bud abscission in Phalaenopsis and flower abscission and decay in Saint Paulia. No obvious quality loss was observed in dark stored Dracaena plants.

None of the light treatments (including some variants using more dense packaging and reflective materials) significantly improved quality of the plants as judged by an overall plant quality score and as judged by the number of abscised leaves or flowers. Application of higher light intensities than used in this experiment may prevent quality loss as reference plants (placed at 20°C, a relative humidity of 80% and 13μmol/m^2/s fluorescent light [12 hours per day]) did not show any quality loss. Application of higher light intensities, however, is considered unattractive due to the consequences of low packing density during transport and increased energy use.

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Introduction

A recent feasibility study from AFSG on the transportability of potted plants in marine Reefer containers showed that optimisation of current available post-harvest methods (temperature, RH, packaging, CA, chemical treatments etc.) did not cause significant improvements.
A proven method to enhance transportability is the use of an adaptation period with lower light and low RH conditions before transport. Importers consider this as not practical applicable in countries like China, Costa Rica and Thailand.
The only possibility left to create significant better transport conditions for potted plants in Reefer containers may be the use of PAR-light (photosynthetic active radiation) during transport. Especially for plants that experience dark-stress related quality problems this may form a break through method
New light sources such as LEDs have recently been used as supplemental lighting during cultivation. Besides that LEDs produce light in the correct wavelength range, they are low energy consumption and don't produce any extra heat.
Regarding the last improvements described previously and following the wishes of the consortium constituted by Maersk Line and Flora Holland bv.; an exploratory test has been conducted with 2 foliage pot-plants varieties and two varieties of flowering plants under diverse light conditions and two storage periods.
Visual inspections were performed to determine effects of the light treatments to determine if there are any future prospects of light addition during sea-transport of potted plants.

1 Material and Methods

1.1 Plants:

After discussion with Flora Holland and taking into account the natural susceptibility of pot-plants to dark-stress and the actual economical importance of pot-plant in Europe, it was decided to conduct the present experiment with fours pot-plants species. The four species are:

- Dracaena marginata
- Saint Paulia hybrids
- Ficus Benjamina
- Phalaenopsis cultivar 'Anthura Gold'

The plants were grown in the Netherlands. They were packed under normal export conditions with carton packaging for Saint Paulia and plastic cover for Phaleanopsis. They were regrouped at Flora Holland in Naaldwijk and transported to A&F facilities.
For each treatment, 15 plants of each species were stored and evaluated.

1.2 Storage conditions:

1.2.1 Storage :

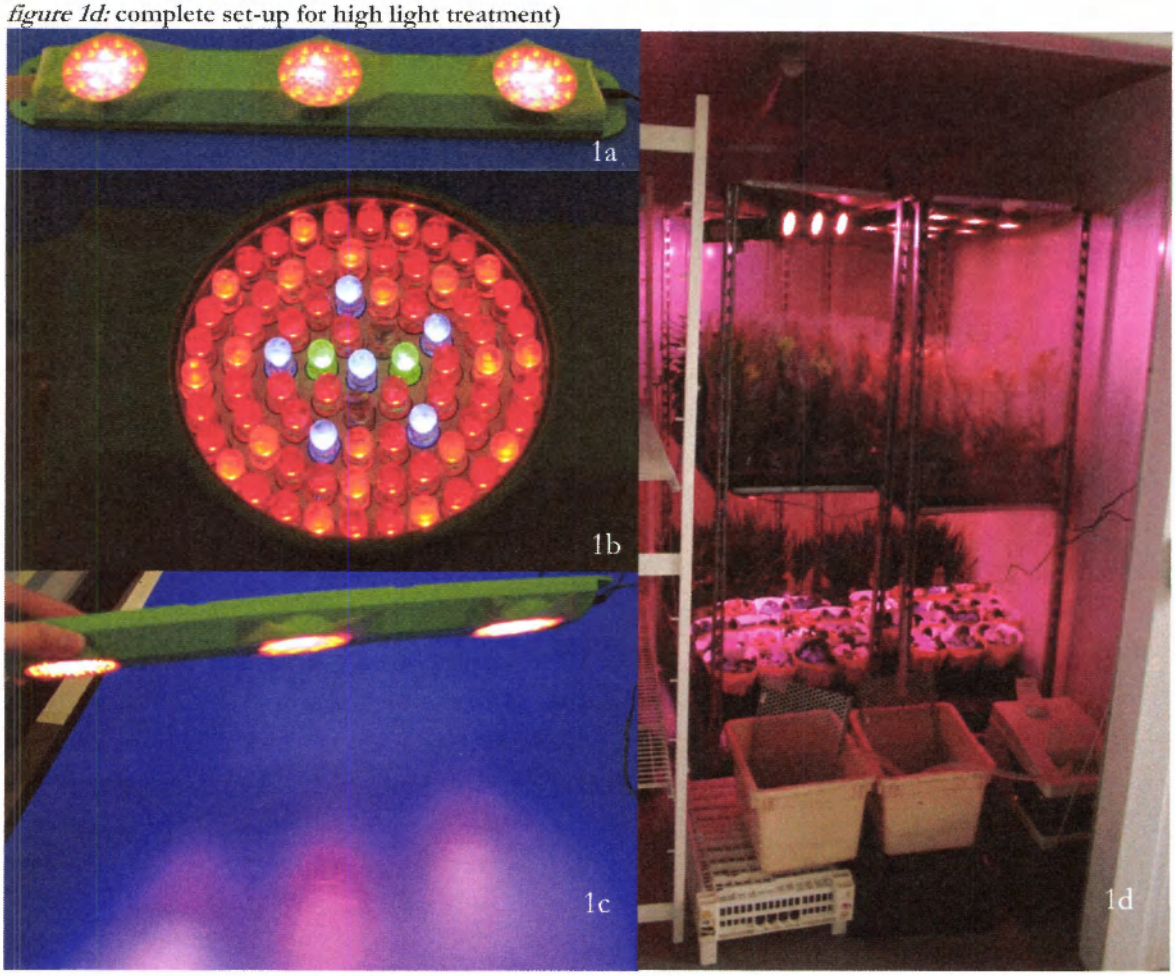
A container transport simulation was processed at A&F facilities. Transports from South America and from Asian continents were simulated by a storage time of 20 and 35 days at 15°C, respectively. As the moisture inside a container during transport is usually high, the relative humidity inside the storage cooling rooms at A&F was maintained between 80 and 90% by placing humidifiers in the rooms.

1.2.2 Light equipments and treatments:

The lamps were provided by LED Import B.V., a Dutch company. The light was produced by assembling 3 spots of combined LED lights (figure 1a). Each spot was constituted by several small LEDs, which produced individually their own wavelength and intensity. The majority of LEDs was producing a red light although some blue, yellow and green light were supplementing the light spectrum to fulfil the plant wishes (figure 1b). The light was produced by these LEDs' complex and was projected as a spot against the plant. To improve the light dispersion, some plastic covers were added. (figure 1c)
3 storage rooms were used to conduct this experiment, one room for each light treatment. The light treatments consisted of 1) dark treatment, 2) low light intensity and 3) high light intensity treatments. The correct light intensity was obtained by adjusting the distance between the lamps and the pot-plants. Intensities of 5μmol/m^2/s and 8μmol/m^2/s respectively for one and 3 light

sets per shelve were reached during the experiment (figure 1d). To avoid any photo-periodism troubles during the shelf life, a photoperiod of 16 hours light, and 8 hours dark was employed for the light treatments. Plants were well watered before the storage treatment. They were watered once more during the transfer to the shelf life room and 2 times more during this shelf-life period.

Figure 1: Light equipments and set up used for light simulation. (*figure 1a:* combination of 3 spots of LED's; *figure 1b:* LED's distribution according the colour light emitted; *figure 1c:* light dispersion ; *figure 1d:* complete set-up for high light treatment)



Extra light set ups were tested with Ficus benjamina in order to adapt packaging or light distribution during transport. 3 extra treatments were carried out:

- extreme low light treatment: an extra diffusivity membrane was placed during the LED lamps and the plants. Thanks to this construction, the light intensity was reduced to 2-3 $\mu mol/m^2/s$.
- higher plant density: to maximise the quantity of plant transported by container, increasing the density of plant per square meter has been tested in combination with the light treatment

- reflector packaging: to assure a homogeneous light distribution, Ficus were packed inside a box with reflector material lined on its inner sides.

1.2.3 Shelf life:

After this transport simulation, plants were transferred to a 15 days shelf life simulation where each plant was judged on several quality attributes according to a standard score sheet. The shelf life simulation was done at a temperature of 20°C, a relative humidity of 70% and 13μmol/m²/s fluorescent light (12 hours per day).

1.2.4 Evaluation protocol and parameters:

In order to determine visually the influence of dark and light treatments, photos of plants were taken before storage, at the beginning of the shelf life period and after 2 weeks. Plants were always positioned on the same position, focus and level of the photo camera were also fixed to be able to compare pictures. A scale was placed near to the plants to determine the size of plant and to establish any growth of the plant that may occur during the storage and shelf life periods. Plant's weight was recorded also before and after storage period in order to follow the water loss and other plant decays that have occurred during the treatment.
The foliage pot-plants as Dracaena and Ficus benjamina were scored according to the following characteristics:

- general overview (see description in table 1)
- number of rots
- number of leaves damaged or broken
- number of leaves yellow or with chlorosis
- number of leaves dried or dropped
- number of leaves with extremity damaged
- number of new leaves growth during the treatment

To determine the general overview of plant after light treatments, the plants were judged according to the scale presented in table 1. These judgement's criteria try to mimic the customer's behaviours during the purchase act.

Table 1: Rating scales applied for the evaluation of pot-plant during shelf life period

Rating	Criterion	Description
Evaluation of foliage		
3	Excellent	Completely healthy leaves and stems, no wilting
2	Good	Wilting and /or yellowing in a few leaves or minor fungal infection. Excellent after removal of unacceptable leaves
1	Moderate	Intermediate number of leaves wilting, yellowing or abscised or with intermediate fungal infection

0	Bad	Large number of leaves wilting, yellowing or abscised or severe fungal infection. Desiccated plants
Evaluation of inflorescence		
3	Excellent	All flowers or buds present, no fungal infection, no abscission
2	Good	Some flowers senescent or showing petal abscission or minor fungal infection. Excellent after removal of unacceptable flowers or leaves
1	Moderate	Intermediate number of flowers and buds abscised, or with intermediate fungal infection.
0	Bad	Large number of flowers and buds abscised or wilted. Severe fungal infection

Source: L. Tijskens et Al. (1996)

The flowering pot-plants as Saint Paulia and Phaleanopsis were judged on their general overview and their flowers. The criteria are resumed in the table 2.

Table 2: Criteria evaluated for flowering pot-plants

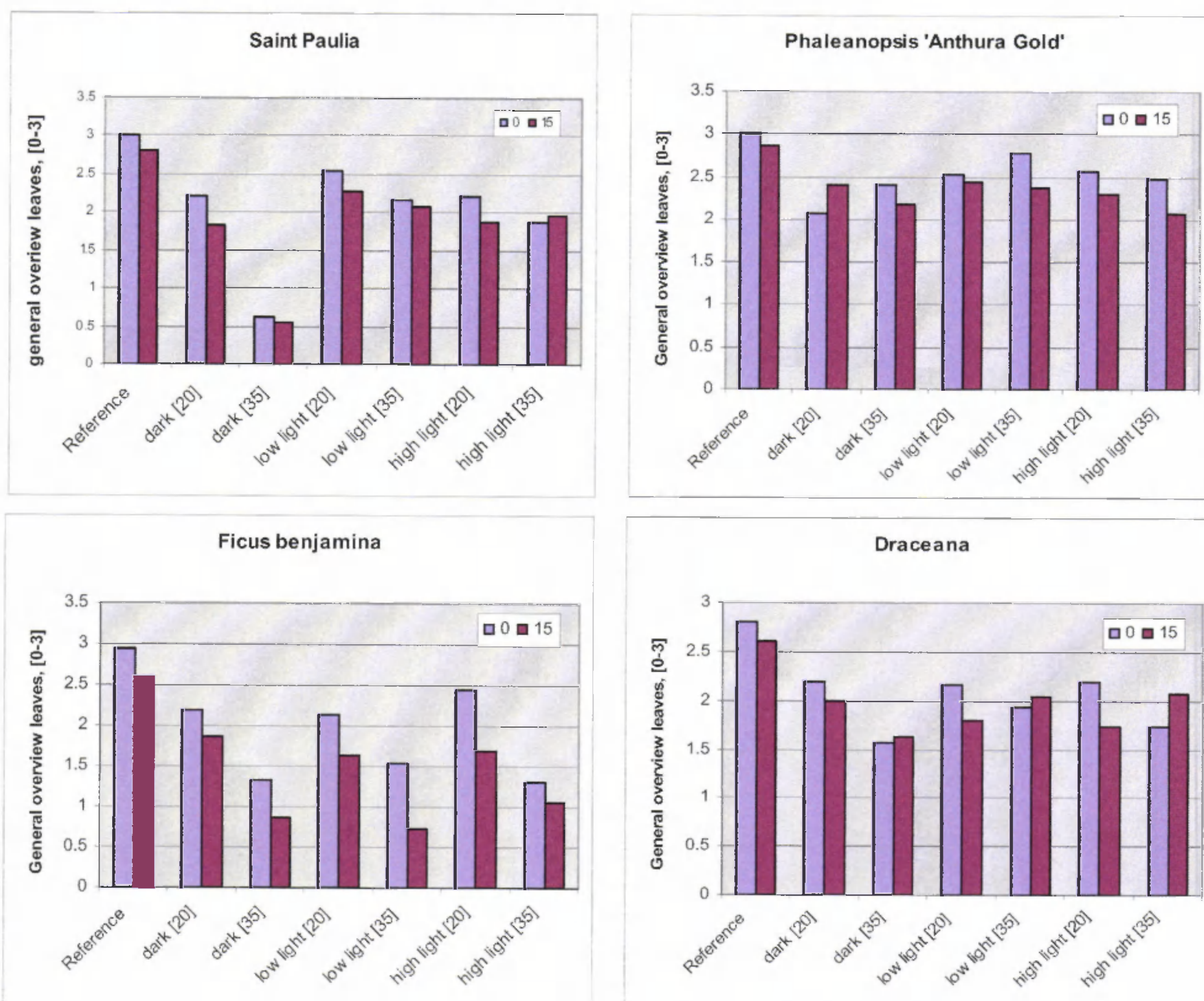
Phaleanopsis		Saint Paulia
Leaves evaluation		
	• General overview • Number of Rots • Number of leaves damaged or broken • Number of leaves yellow • Number of dried leaves or dropped	
Flower evaluation		
	• General overview (inflorescence)	
• Number of small buds • Number of big buds • Number of flower opened • Number of buds/flowers dropped		• Number of wilted bouquets • Intensity of wilted

2 Results:

2.1 Foliage evaluation

Dark stress induced leaf abscission in Ficus. The leaves of the other species did not show signs of dark stress.

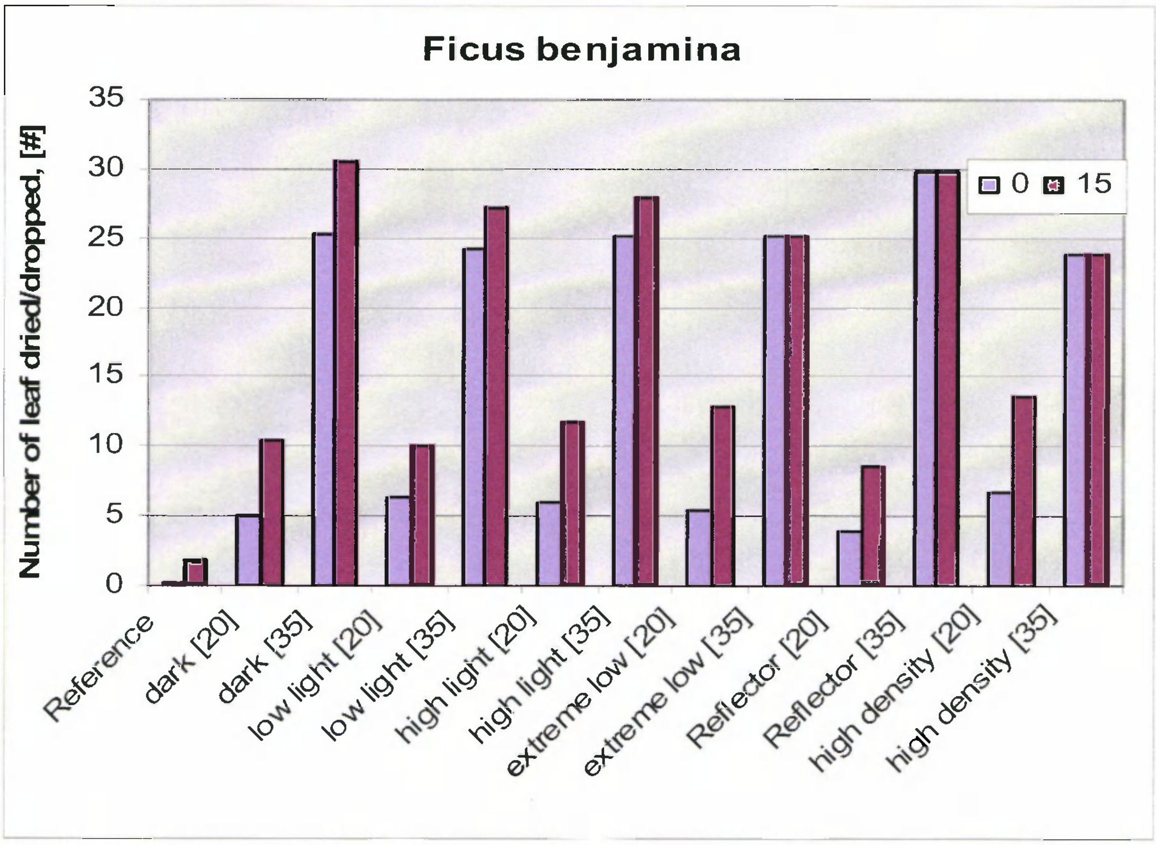
Figure 2: General overview of plant leaf quality immediately after 20 or 35 days transport simulation (blue bars) and after 15 days in shelf life room (purple bars). Reference refers to plants that were not stored but continuously held under shelf life conditions.



The overall leaf quality was not much influenced by the light treatments. The low mark of Saint Paulia given for the dark treatment (35 days) is due to rot development. Rot is the result of combination of light stress induced by the treatment and high relative humidity inside the storage room.

The most important light stress symptom observed in Ficus benjamina is the leaf drop. Figure 3 shows the number of leaves dropped over time and according to treatments received. As expected, Ficus benjamina is extremely light stress sensitive. The severity of leaves drop depends on the intensity of the stress undergone and the duration of the treatment. According to the figure 3, the light treatment didn't permit to reduce the effect of dark stress. Indeed the leaf drop observed with the same severity whatever the treatments, excepted for the reference treatment. These results suggest light storage treatment should use higher light intensity, near to intensity used for reference treatment (13μmol/m²/s).

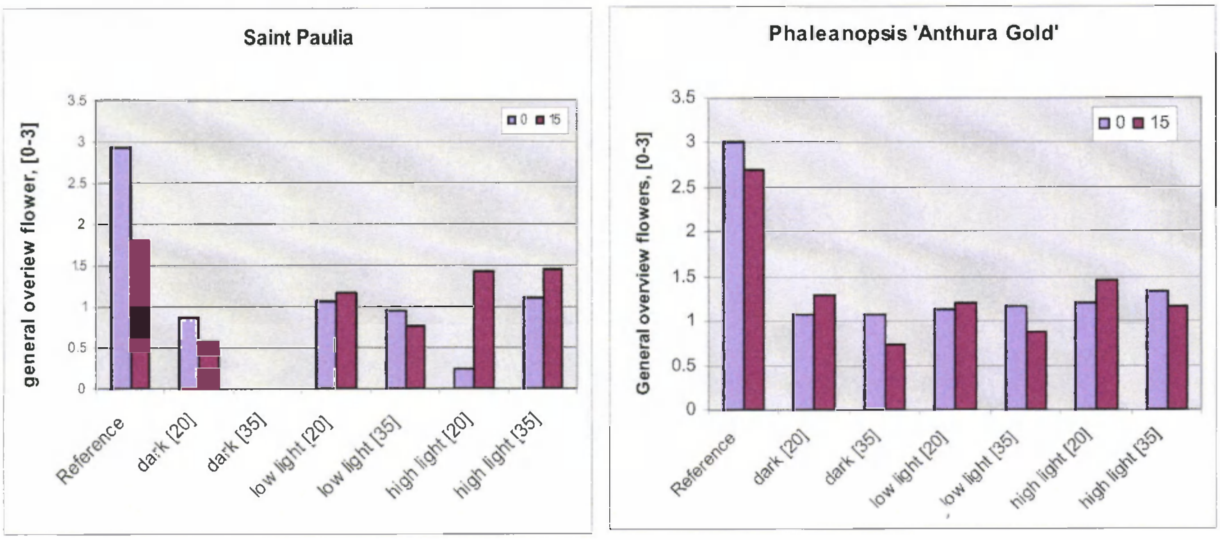
Figure 3: Number of leaves dropped immediately after 20 or 35 days transport simulation (blue bars) and after 15 days in shelf life room (purple bars). Reference refers to plants that were not stored but continuously held under shelf life conditions.



2.2 Flower evaluation

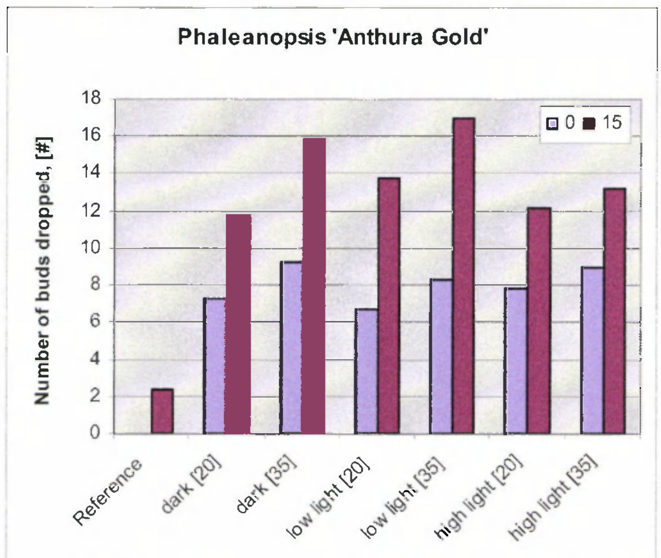
Figure 4 shows the average quality of flowers per treatment. For both flowering plants, the transport simulation has a negative effect on the inflorescence. No significant differences are visible between dark and light treatments. The low mark of Saint Paulia given for the dark treatment (35 days) is due to rotting process of the complete plants. Rot is not considered as direct and exclusive result of dark stress; but this stress plays a role non-negligible in the quality degradation of plants.

Figure 4: General overview of plant flower quality immediately after 20 or 35 days transport simulation (blue bars) and after 15 days in shelf life room (purple bars). Reference refers to plants that were not stored but continuously held under shelf life conditions.



The number of buds dropped after transport simulation in Phalaenopsis is shown in figure 5. No significant difference is observed between the treatments.

Figure 5: number of buds dropped quality immediately after 20 or 35 days transport simulation (blue bars) and after 15 days in shelf life room (purple bars). Reference refers to plants that were not stored but continuously held under shelf life conditions.



To visualize the differences induced by the treatments (see figure 6, 7, 8 and 9), several pictures were taken at the same storage stage to be able to evaluate the physical damages induced by light or other stresses. These pictures confirm the results presented above:

- Dracaena are not light sensible and any decays are nearly invisible whatever the transport simulation treatments (figure 6)
- Ficus. important foliage decays are visible whatever the light simulations run for 35 days. Plants show significant leaves dropping on the lower part of the plant (figure 7).
- Phaleanopsis: the main difference between the treatments is visible on the flowering stem of the plants. Indeed the figure 8 shows the different advanced flower stages reached according to the storage treatment. By this visual reporting, it is clear that reference plants have the best flower stage compared to the light treatment.
- Saint Paulia: the figure 9 shows the main decays happened during the transport simulation. The inflorescences of the plants after dark treatment are rotted; this process is likely a combination of dark stress and high relative humidity.

Figure 6: Photos of Dracaena pot-plants taken after transport simulation treatments (20 days) and 15 days in shelf life room. (A: reference plant directly placed in shelf life room, B: Dark treatment, C: low light treatment and D: high light treatment)

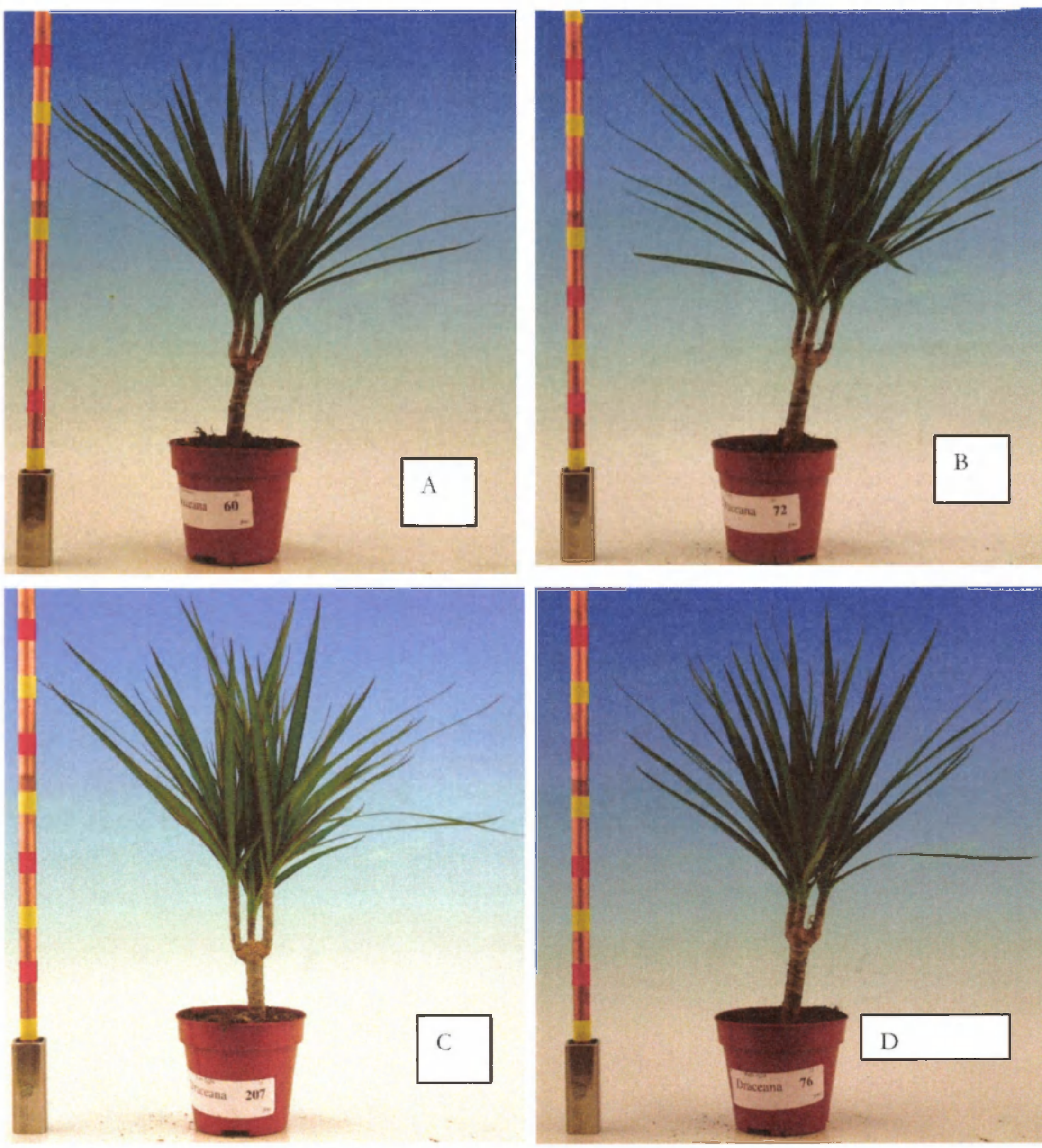


Figure 7: Photos of Ficus benjamina pot-plants taken after transport simulation treatments (35 days) and 15 days in shelf life room. (A: reference plant directly placed in shelf life room, B: Dark treatment, C: low light treatment and D: high light treatment)

Figure 8: Photos of Phaleanopsis 'Anthura gold' pot-plants taken after transport simulation treatments (35 days) and 15 days in shelf life room. (A: reference plant directly placed in shelf life room, B: Dark treatment, C: low light treatment and D: high light treatment)

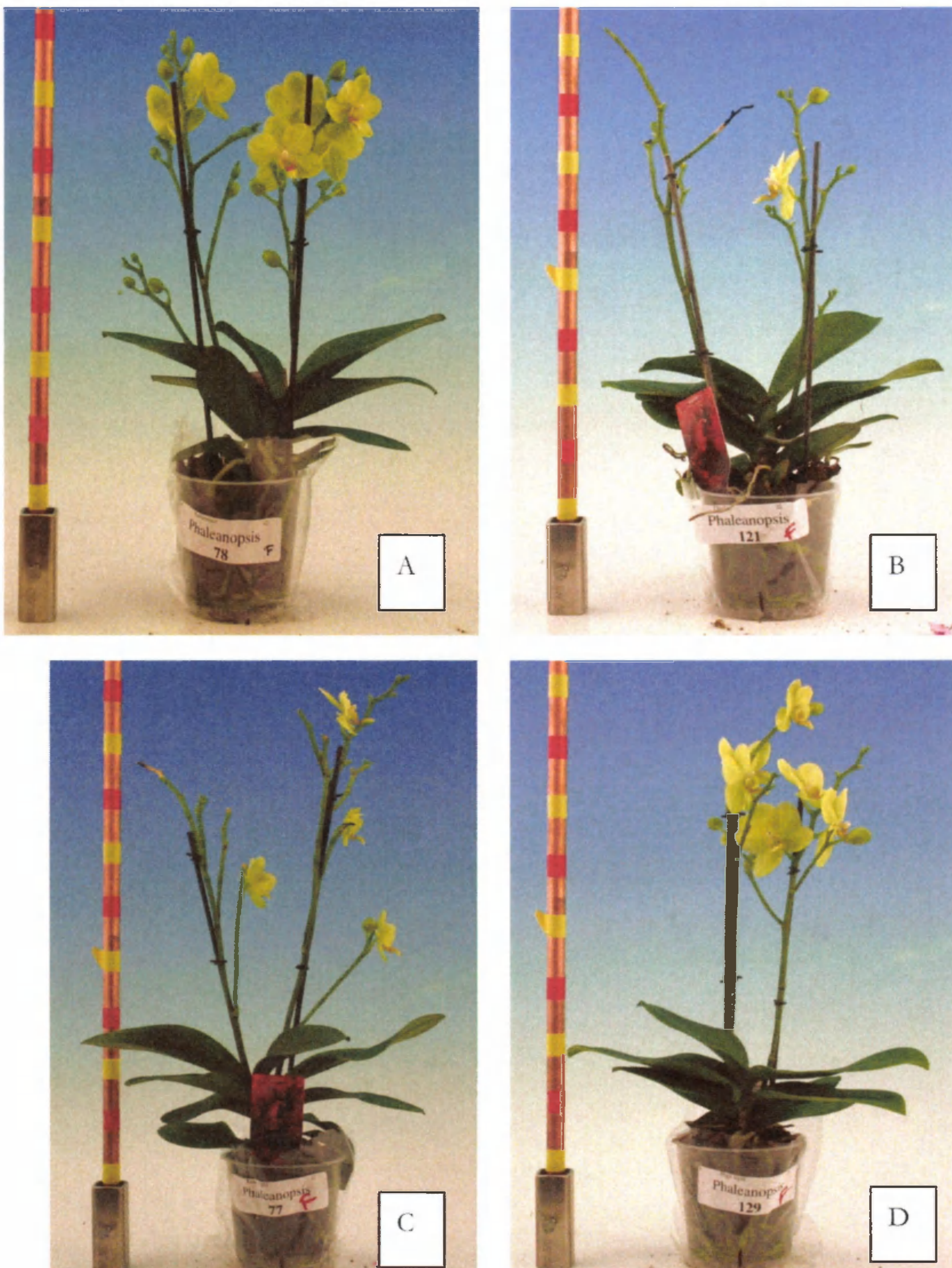
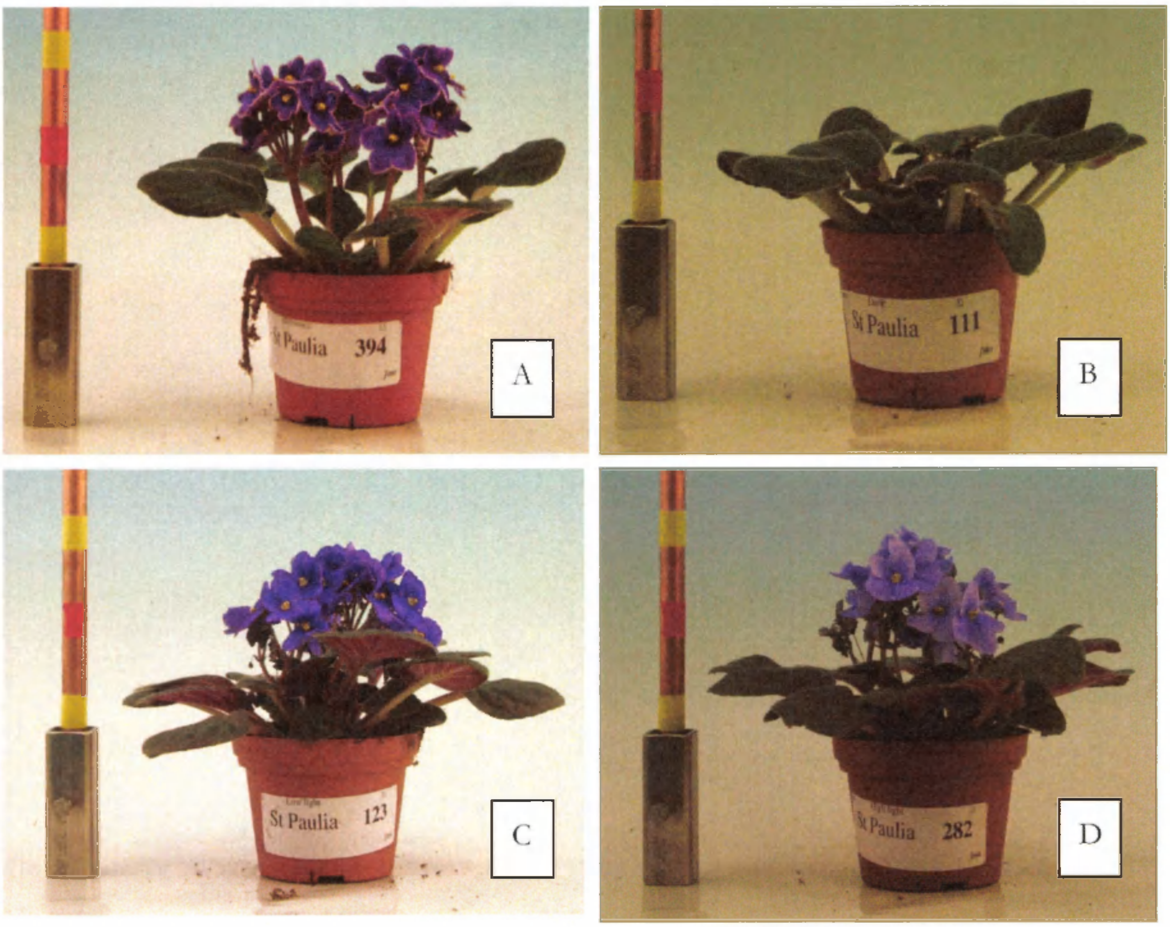


Figure 9: Photos of Saint Paulia pot-plants taken after transport simulation treatments (35 days) and 15 days in shelf life room. (A: reference plant directly placed in shelf life room, B: Dark treatment, C: low light treatment and D: high light treatment)



2.3 Extra treatments:

The general overview (figure 10) shows clearly the quality decays observed in Ficus after 35 days of storage. Quality decay was not affected by any packaging treatments. Indeed, no significant differences are visible between the 3 treatments and the general overview marks given for low light treatments (see figure 2).

The evolution of plant's qualities during the transport simulation (figure 11) was also studied by taking pictures of the same plants at several times during treatment. This overview shows the precise location of the main decays observed during the treatments. Ficus benjamina drops leaves at the base of plant.

Figure 10: General overview of Ficus benjamina quality immediately after 20 or 35 days transport simulation (blue bars) with packaging variants and after 15 days in shelf life room (purple bars).

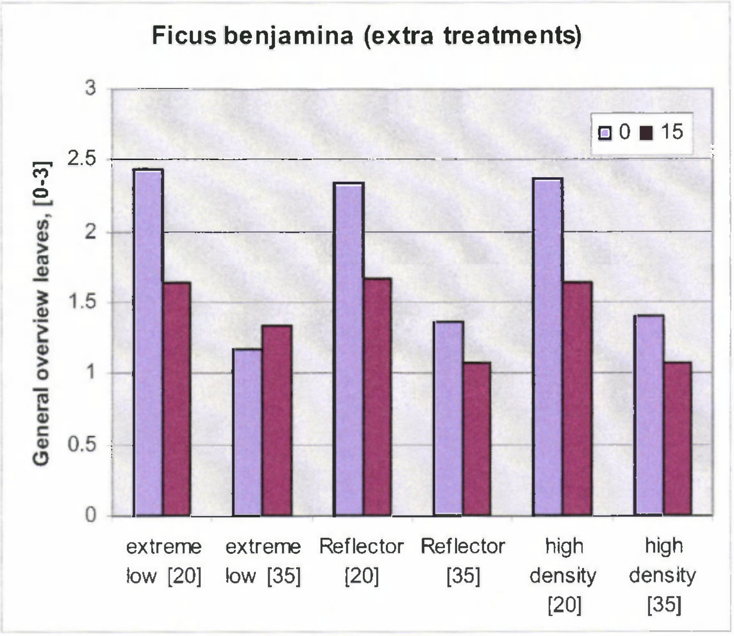


Figure 11: Photos of Ficus benjamina pot-plants being treated 35 days with a really low light intensity (1), packed with high density of pot-plnats per area (2) and packed inside a box with reflector material (3).

Conclusions:

The effects of application of LED lighting during long-term storage of potted plants were investigated. Plants (Ficus benjamina, Phalaenopsis, Saint Paulia and Dracaena) were stored at 15°C for 20 and 35 days either in the dark or under low light intensities 5µmol/m²/s and 8µmol/m²/s (for 16 h a day) provided by LEDs. Dark storage induced leaf abscission in Ficus, flower and bud abscission in Phalaenopsis and flower abscission and decay in Saint Paulia. No obvious quality loss was observed in dark stored Dracaena plants.

None of the light treatments (including some variants using more dense packaging and reflective materials) significantly improved quality of the plants as judged by an overall plant quality score and as judged by the number of abscised leaves or flowers. The severe deterioration (flowers and leaves infected with fungal pathogen) of Saint Paulia in the 35 days dark treatment is due to a rotting process. These symptoms have appeared when the combination of light stress and the high relative humidity inside climate room during storage is met during the treatment.

Application of higher light intensities than used in this experiment may prevent quality loss as reference plants (placed at 20°C, a relative humidity of 80% and 13µmol/m²/s fluorescent light [12 hours per day]) did not show any quality loss. Application of higher light intensities, however, is considered unattractive due to the necessity to accept loose packaging density. Also the increased energy use may be a factor.

Literature:

L.M.M. Tijskens, M.Sloof, E.C. Wilkinson, W.G. van Doorn. (1996). "A model of the effects of the temperature and time on the acceptability of potted plants stored in darkness." Postharvest biology and Technology 8:293-305