Factors affecting quality and post-production life of \textit{Exacum affine}

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Abstract

Two cultivars of \textit{Exacum affine}, White Princess and Royal Dane, were grown under supplementary light conditions (70 and 100 \(\mu\)mol m\(^{-2}\) s\(^{-1}\)). The higher light intensity reduced the production time and resulted in increased flower development during the post-production period in an interior environment. To test ethylene responses, the plants were sprayed with the anionic silver thiosulphate complex (STS) and then exposed to 3.5 \(\mu\)l l\(^{-1}\) ethylene or kept in an ethylene-free environment. The post-production quality and life of \textit{Exacum} plants were reduced by the presence of exogenous ethylene. Inhibition of ethylene action improved post-production flower numbers even in the absence of ethylene. © 2000 Elsevier Science B.V. All rights reserved.

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1. Introduction

Potted flowering plants of \textit{Exacum affine} Balfin are increasingly important both in the USA and Europe. The genus \textit{Exacum} is a member of the Gentianaceae. Its species are distributed over a wide range from the central zone of Africa, including Madagascar, to the Arabian peninsula, eastern India, the Himalayas and Sri Lanka, through Malaysia to the eastern tip of New Zealand (Riseman and Craig, 1995). \textit{E. affine} Balfin was first introduced into Denmark as a potted plant in the mid-1970s from seeds imported from Japan and the USA. After some years of breeding, new European cultivars were released in the 1980s.
Fundamental studies of *E. affine* that have been conducted include taxonomic, cytogenetic and morphological evaluations of different species and hybrids (Torres and Natarella, 1984). The few applied studies that have been undertaken include optimization of growing conditions, such as temperature, irrigation, fertilization, and evaluation of flowering responses (Harbaugh and Waters, 1982; Rubino, 1991). However, there has been little study of either the effects of growing conditions on quality and post-production life of these plants or on the behavior of the potted plants during storage, transportation and in the consumer’s home.

Photosynthesis is one of the most important factors in plant growth and development. Starch and sugar synthesized during photosynthesis are stored in the stems, leaves and petals, and provide the food essential for flower opening and maintenance during post-production. The post-harvest life of potted plants and cut flowers is often limited by their inability to maintain photosynthesis under the lighting conditions of the interior environment where they are held, so it is important to ensure high carbohydrate levels in plants at harvest time. This can be achieved by growing plant under optimum light conditions.

The quality and post-harvest life of many plants and flowers are often reduced by the presence of ethylene in the environment. Ethylene has a variety of deleterious physiological effects, such as bud, flower or leaf abscission and senescence (Reid, 1985). Improved quality in ethylene-sensitive plants can be achieved by application of silver thiosulphate (STS), an inhibitor of ethylene action (Veen, 1983; Serek, 1993). Woltering (1987), in a comprehensive study of 52 plant species and their ethylene sensitivity, classified *Exacum* as a slightly sensitive plant. He reported that exposure to 15 μl l⁻¹ ethylene for 72 h caused senescence of *Exacum* flowers.

Here in, we examine the hypothesis that post-production quality and life of *Exacum* plants will be improved by production under supplementary lighting and by post-harvest treatment with STS to overcome the effects of ethylene.

2. Materials and methods

2.1. Plant material

Potted *E. affine* plants cv. Royal Dane and White Princess were used. They were grown in a commercial greenhouse for 17 weeks and then transported to the university experimental greenhouse for the final production period. Finishing conditions were 20°C day/night, 65% RH and 500 ppm CO₂.

2.2. Effects of light intensity

Plants were divided into two groups and each group was placed under supplementary light conditions, either 100 or 70 μmol m⁻² s⁻¹, from SON-T
high-pressure sodium (HPS) lamps (Philips, the Netherlands) for 16 h per day. Plants were watered when needed (approx. every 5–6 day) with a complete nutrient solution (EC 1.0–1.4 mS cm$^{-1}$ and pH approx. 6.0).

When the plants reached commercial maturity with approx. 20 open flowers per plant, they were transferred to simulated transport conditions (3 days in darkness at 22°C). After transport simulation, plants were placed in the interior environment room (IE): temperature 22°C, 15 μmol m$^{-2}$ s$^{-1}$ fluorescent light for 12 h per day and RH 65%. Watering was when needed with tap water.

Data collected included the number of days from transfer of plants to the university greenhouse to achieving commercial maturity, height and diameter of the plants and number of flowers per plants at commercial maturity. The number of flowers was also counted after 3 days simulated transport and every 5th day until the end of experiment.

2.3. Effects of ethylene and STS

*Exacum* plants cv. Royal Dane and White Princess at commercial maturity were placed in an IE room as described above. They were divided into two groups and sprayed with either 0.5 mM STS or DI water. Half of the plants of each group were enclosed in gas-tight chambers continuously ventilated with 3.5 μl l$^{-1}$ ethylene for 7 days. The remainder were ventilated with ethylene-free air in identical gas-tight chambers. After 7 days, all plants were removed from gas-tight chambers and placed in the IE until the end of the experiment. Environmental conditions in the chambers were similar to those in the IE, except for a higher RH of about 95%. Numbers of open and wilted flowers were determined at the beginning of the experiment, at day 7 and then every 5th day until the end of the experiment.

2.4. Statistics

Statistical procedures were performed using the PC-SAS software package. Differences between means were determined by $t$-test or orthogonal comparisons.

3. Results

3.1. Effect of finishing light intensity on production and post-harvest characteristics of *Exacum* plants

The higher light level during the finishing period reduced the number of days to commercial maturity in both tested cultivars. Plants grown under
100 μmol m⁻² s⁻¹ were ready for sale after 47 days; plants grown under 70 μmol m⁻² s⁻¹ needed 52 days to achieve the same stage. There were no significant differences in plant height or plant diameter between irradiance treatments or between cultivars (data not shown). The number of open flowers during post-harvest period were highest on plants grown under higher light level (Fig. 1A and B) for both investigated cultivars. Under low light conditions White Princess developed more flowers than Royal Dane. No differences in number of flowers between cultivars were observed for plants irradiated with 100 μmol m⁻² s⁻¹.

Fig. 1. Number of open flowers per *E. affine* cultivar Royal Dane and White Princess, before and after 3 days transport simulation, and subsequently every 5th day during storage in an IE room. Before storage, plants were grown under different light conditions of 100 or 70 μmol m⁻² s⁻¹. Statistics are as follows. Royal Dane: 100 vs 70 μmol m⁻² s⁻¹, Lns Q***; White Princess: 100 vs 70 μmol m⁻² s⁻¹, L*** Qns; Royal Dane 70 vs White Princess: 70 μmol m⁻² s⁻¹, L*** Q***; Royal Dane 100 vs White Princess: 100 μmol m⁻² s⁻¹, Lns Qns; (ns, *** non-significant or significant at 0.001, respectively).
3.2. Ethylene sensitivity and the effects of STS

Exposure of plants for 7 days to a low concentration of ethylene resulted in a 50% decrease of open flowers for both cultivars (Fig. 2A and B). After removal of the plants from the ethylene chamber to the IE, the number of flowers increased somewhat over a few days, then decreased steadily (Fig. 2A and B). The effects of ethylene were largely prevented by pre-treatment with STS, although not to the level of the ethylene-free air treated plants. Interestingly, though, STS pre-treatment improved the quality of plants held in an ethylene-free environment.

Fig. 2. Number of open flowers per *E. affine* cultivar Royal Dane and White Princess treated with 0.5 mM STS or air control, exposed to 3.5 ml l⁻¹ ethylene for 7 days or kept in ethylene-free air. Statistics are as follows. Royal Dane: STS/ethylene vs control/ethylene, $L^{***} Q^{***}$; Royal Dane: STS/air vs control/air, $L^{***} Q^{*}$; White Princess: STS/ethylene vs control/ethylene, $L^{***} Q^{***}$; White Princess: STS/air vs control/air, $L^{***} Q^{***}$; (*, *** significant at 0.05 or 0.001, respectively).

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These plants had substantially more flowers than control plants. This effect was more pronounced in White Princess than in Royal Dane.

4. Discussion

Beneficial effects of supplementary lighting during production have been shown for a range of flowering potted plants and cut flowers (Fjeld, 1990a,b; Serek, 1991). In the present study, high light during finishing decreased production time and increased flower opening during the post-harvest period for each of two Exacum cultivars. Similarly, Campanula carpatica grown under 100 μmol m$^{-2}$ s$^{-1}$ developed more flowers, with larger flower area, compared to those grown under 70 or 40 μmol m$^{-2}$ s$^{-1}$ (Serek, 1991). High light levels for Christmas begonia (Begonia × cheimantha Everett) during production resulted in accelerated production and improved development of buds and flowers in the post-harvest period (Fjeld, 1990a). At sale stage the starch content in the leaves of begonias grown under 60 μmol m$^{-2}$ s$^{-1}$ was double that of plants grown under 15 μmol m$^{-2}$ s$^{-1}$ (Fjeld, 1990b). It seems probable that the effects that we observed in Exacum finished under high light intensity are the result of increased carbohydrate in the plant. Moreover, they might reflect increased production of flower initials during finishing.

There has been little study of the ethylene sensitivity of Exacum. Woltering (1987) rated Exacum as being only slightly sensitive, based on observing only flower senescence after exposure to 15 μl l$^{-1}$ ethylene for 72 h. Heijkenskjöld (1978) concluded that Exacum was not sensitive to ethylene. However, his conclusions were based on the effects of a shorter 48 h exposure to ethylene at the relatively low temperature of 15°C. Our data suggest higher sensitivity, since we found dramatic reduction in open flowers after 7 days exposure to 3.5 μl l$^{-1}$ ethylene and saw continuing effects after ethylene exposure had ceased. That the number of open flowers was increased in air-treated plants that had been treated with STS suggests that flower senescence in Exacum is mediated naturally by ethylene.

We conclude that faster finishing and increased flower development can be achieved by growing Exacum under high supplementary lighting. Ethylene effects can be prevented by STS treatment, which also appears valuable in improving the post-production of plants even if they are not exposed to ethylene.

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References


