

Effect of Benzylaminopurine, Gibberellic Acid, Silver Nitrate and Silver Thiosulphate, on postharvest longevity of cut leaves of *Dracaena*

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ABSTRACT

Leaf yellowing associated with early senescence is a major problem associated with cut decorative leaves and flowers of many tropical plant species. Effect of postharvest application of benzylaminopurine (BAP), gibberellic acid (GA₃), silver-thiosulphate (STS) and silver nitrate (AgNO₃) on vase life of cut leaves of three *Dracaena* species *Dracaena marginata* 'bi colour', *Dracaena sanderiana* 'white' and *Dracaena deremensis* were investigated. Deionized water (DIW) was used as the control. All the BAP treatments (25, 50 and 100 µM) applied either as 10 minutes immersion or as 24 h pulse improved the vase life of all three species examined. Application of STS (2 mM) and AgNO₃ (10 mM Ag ions) did not increase the vase life of *D. marginata* 'bi colour' and *D. sanderiana* 'white' significantly while GA₃ (50, 100 and 250 µM) either as a pulse or immersion, significantly reduced the postharvest life of *D. deremensis* compared to untreated leaves. Results suggest that the application of 25 µM BAP as a pulse treatment for 24 h can be recommended to prolong the postharvest life through delayed leaf senescence and thus enhance the marketability of cut leaves of *Dracaena marginata* 'bi colour', *Dracaena sanderiana* 'white' and *Dracaena deremensis*.

Key words: postharvest life, *Dracaena marginata* 'bi colour', *Dracaena sanderiana* 'white', *Dracaena deremensis*, marketability

INTRODUCTION

Dracaena is a genus of about 40 species of trees and succulent shrubs classified in the family Ruscaceae in the APG II system, or separated (with *Cordyline*) into a family of their own, Dracaenaceae or in the Agavaceae (Anon., 2011). Some shrubby species, such as *Dracaena deremensis*, *D. fragrans*, *D. godseffiana*, *D. marginata* and *D. sanderiana* are popular as houseplants and are used to decorate homes, offices, malls, apartments and the landscape around the world (Anon., 2011). Rooted stem cuttings of *D. sanderiana* are widely marketed in the U.S.A. as "Lucky Bamboo" (Anon., 2011). The demand for shoot-tops of *D. marginata* and *D. sanderiana* is still increasing in Europe (Ladha, 2011). Sri Lanka has the potential to supply *Dracaena* to the European and USA markets due to the climatic conditions favourable for the growth of *Dracaena* in the country. In order to compete in the international market, exporters must be able to supply good quality plant products on a regular basis and should be able to maintain the quality during the marketing process. Loss of appealing quality

characteristics and rapid desiccation within a short period after detaching from mother plants is one of the major problems in exporting foliage plant species from Sri Lanka (Perera *et al.*, 2009). Detachment of flowers and leaves usually advances the onset of senescence resulting in rapid breakdown of macro molecules including proteins, RNAs and membrane lipids causing an outflow of non-protein nitrogen, lipids and nucleic acid components through the leaky membranes (Arteca, 1996). Loss of chlorophyll which occurs as a result of chloroplast degradation is one of the indicators of the senescence process of cut foliage. The onset of senescence of cut foliage may be induced by various external factors such as temperature, moisture content, gases, radiation and pathogens, while internal factors related to senescence are regulated mainly by two phytohormones, ethylene and abscisic acid (ABA) (Weaver *et al.*, 1998). In contrast, cytokinins delay senescence of cut foliage mainly by maintaining the integrity of the tonoplast membrane and preventing leakage of proteases which hydrolyse the soluble proteins of chloroplast and mitochondrial membranes (Thinmann, 1980). Gibberellins are known to delay senescence by

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preventing the loss of chlorophylls and degradation of RNA and proteins in cut foliage (Arteca, 1996).

Wilting and leaf yellowing are the predominant postharvest problems associated with cut foliage, and use of preservatives has shown to be effective in retarding these processes. Silver nitrate (AgNO_3) and silver thiosulphate (STS), which interfere the binding sites of ethylene, are the common forms of silver salts used in commercial flower preservative solutions. Pulsing with AgNO_3 has reported to enhance the vase life of roses (Singh and Tewari, 2002; Darras *et al.*, 2010; Elgimabi, 2011) and Anthuriums (Paull and Goo, 1982) by interfering with ethylene binding. Silver ions delay senescence not only through inhibiting the ethylene binding, but also through acting as a biocide thus eliminating the microbial blockage of the xylem vessels and maintaining the hydraulic conductivity of the stems (Ohkawa *et al.*, 1999; Ichimura, 2003).

External supply of cytokinins and gibberellins has also been reported to reduce leaf chlorosis and yellowing in several cut foliage and flower species (Skutinik *et al.*, 2001, Ranwala *et al.*, 2003, Mutui *et al.*, 2006, Singh *et al.*, 2008). However, the efficiency of plant growth regulators (PGRs) in delaying senescence and enhancing postharvest life depends on the plant species used (Paull and Chantrachit, 2001), type and concentration of preservative solution and the method of application (Ranwala *et al.*, 2003).

The present study was carried out to identify suitable postharvest treatments that would enhance the vase life of cut foliage of three *Dracaena* species; *D. marginata* 'Bi colour', *D. sanderiana* 'White' and *D. deremensis*.

MATERIALS AND METHODS

Plant materials and laboratory procedures

Top cuttings of *D. marginata* 'Bi colour' and *D. sanderiana* 'White' shoots were harvested from a commercial farm at Kalagedihena while top cuttings of *D. deremensis* were obtained from plants grown in a net-house in the Royal Botanic Garden at Peradeniya, Sri Lanka. Harvesting of leaves was done between 07.00-08.00 am. Their cut ends were immersed in deionized water (DIW) and the rest of the parts were covered with plastic bags. Cut leaves were transported to the laboratory within 2 h of harvesting. The cuttings were graded for uniformity and stems were recut under DIW using sterile, sharp scalpels.

Different treatment solutions were prepared with Benzylaminopurin (BAP, Sigma-Aldrich, USA), gibberellic acid (GA_3 -Sigma-Aldrich, USA), silver nitrate (AgNO_3 -Sigma-Aldrich, USA) and sodium thiosulphate ($\text{Na}_2\text{S}_2\text{O}_3$). Silver thiosulphate complex (STS) was prepared according to Sigma-Aldrich, USA catalogue (Sigma Aldrich, 2010). Freshly prepared solutions were used in all experiments. Glass jars (375 ml) autoclaved at 120°C and 15 psi were used for the vase life experiments. Experiments were conducted in an air-conditioned room ($22 \pm 1^\circ\text{C}$) under 70-80% relative humidity (RH) with an average radiation of about $20 \mu\text{mol m}^{-2} \text{s}^{-1}$ for 12 h per day.

Effect of Benzylaminopurine, Silver Nitrate and Silver thiosulphate, on Postharvest life of *D. marginata* 'Bi colour' and *D. sanderiana* 'White' cut leaves

This experiment was conducted with the objective of identifying the most effective concentration of selected ethylene-binding inhibitor chemical or PGR for lengthening the vase life of *Dracaena* top cuttings. The effect of STS (2 mM), AgNO_3 (1000 ppm or approx 10 mM Ag ions), and BAP (25, 50, 100 μM) on vase life of cut leaves of *D. marginata* 'Bi colour' and *D. sanderiana* 'white' were investigated. Top shoot cuttings were immersed in each of 200 ml STS, AgNO_3 , and BAP solutions for 10 minutes. Thereafter, cuttings were transferred into glass jars containing 200 ml de-ionized water (DIW). Untreated leaves were placed directly in DIW as the control. The mouths of jars were covered around the stem, with Parafilm (Pechiney Plastic Packaging, Chicago, IL, USA) to prevent evaporation and contamination. DIW in jars was replaced with fresh DIW at 5 day intervals.

Effect of BAP, and GA_3 concentrations and method of application on vase life of *D. deremensis*

Effects of BAP (25, 50, 100 μM), and GA_3 (50, 100, 250 μM) concentrations and two methods of applications on vase life of cut leaves of *D. deremensis* was investigated. Cut leaves were placed in sterile glass jars containing 200 ml of treatment solutions and the treatments applied using two methods, *viz.* pulse conditioning (by placing shoots of top cuttings for 24 h in PGR solutions) or immersion (by immersing cuttings for 10 mins in PGR solutions). Untreated leaves placed directly into DIW were used as control. After treatment, leaves were transferred into glass jars containing 200 ml of DIW and

covered, as described previously. DIW in jars was replaced with fresh DIW at 5 day intervals.

Foliage evaluation

Treated shoot cuttings were evaluated by ranking the colour of leaves according to a self-prepared scale for colour of leaves (fresh looking leaves-3; slightly pale in colour-2; moderately yellow-1, severely yellow-0), for visual condition of leaves (no blemishes-3, slightly brown tips and margins-2; dry and brown tips and margins-1; leaf blade brown -0) and for petiole condition (straight, fresh stem-4; slight brown and bent-3; moderately brown and bent-2, severely brown and bent-1 and dry petioles -0). Vase life of *Dracaena* was determined as the number of days taken for change in the colour of leaves from rank 3 to 2, visual condition from rank 3 to 2 and petiole condition from rank 4 to 3. The overall vase life was set as the day on which the leaves obtained an aggregate value of 7 for colour of leaves, visual condition and petiole condition.

Experimental design and data analysis

The both experiments were arranged in complete randomized design. Each treatment consisted of 3 replicates and each replicate consisted of 5 top cuttings. The data were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) (SAS Institute, Cary, NC, USA). Treatment means were compared by the Duncan's New Multiple Range Test (DNMRT) at 5% probability level.

RESULTS

Experimental findings revealed that immersion of cut leaves of *D. marginata* 'bi colour' and *D. sanderiana* 'white' either in STS or AgNO₃ for 10 min had no effect on prolonging the vase life

in comparison to untreated leaves (Table 1). All the BAP treatments (immersion in 25, 50, 100 µM BAP solutions for 10 min) significantly improved the vase life of the two *Dracaena* species of by 2-5 days compared to the control and, no significant differences among the BAP treatments were observed (Table 1).

Furthermore, both *D. marginata* 'bi colour' and *D. sanderiana* 'white' leaves showed similar changes in vase life with respect to all the treatments. . Even though, treatment with BAP showed slight improvement (2-5 days) in vase life of *D. marginata* 'bi colour' and *D. sanderiana* 'white', it was decided to conduct further investigations to prolong the vase life using two different plant growth regulators (GA₃ and BAP) and two different application methods

Application of BAP (25, 50, 100 µM) improved the vase life of *D. deremensis* (Table 2). Pulsing with BAP was more effective than immersion in the same solutions for 10 min, in extending the vase life (by 1.7- fold at p= 0.05) of *D. deremensis* cut foliage. When *D. deremensis* leaves were pulse-treated either with 25 µM and 50 µM BAP, vase life increased by 1.7-fold (30.9 and 30.19 days respectively) compared to untreated leaves (18.3 days), thereby extending the vase life of *D. deremensis* significantly.

Application of GA₃ significantly reduced the vase life of *D. deremensis* cut foliage. Furthermore, exposure to higher concentrations of GA₃ (100 and 250 µM) for a longer duration (24 h pulsing) significantly reduced the vase life of *D. deremensis* leaves compared to low concentration of GA₃ (50 µM) and higher concentrations of GA₃ (100 and 250 µM) for shorter durations (10 min immersion) (Table 2), inferring that the type of preservative and the method of application is of prime importance for a given cut foliage species.

Table 1. Effect of STS, AgNO₃, and BAP on vase life of *D. marginata* 'bi colour' and *D. sanderiana* 'white'

Treatments	Vase Life (Days)			
	<i>D. marginata</i> 'bi colour',		<i>D. sanderiana</i> 'white'	
Control (DIW)	17.5±1.5	a*	19.0±1.9	a*
STS (2 mM)	18.5±0.9	a	19.8±1.2	a
AgNO ₃ (10 mM)	18.8±0.7	a	18.3±1.5	a
BAP (25 µM)	20.9±0.9	b	21.5±1.3	b
BAP (50 µM)	21.5±1.3	b	22.5±0.9	b
BAP (100 µM)	22.6±1.5	b	22.8±1.8	b
LSD	1.35		1.15	

*Values in each column followed by the same letter are not significantly different at p=0.05

Table 2. Effect of BAP and GA₃ on vase life of *D. deremensis* cut leaves.

Treatment	Vase life (Days)	Increase in vase life times(x) (Vase life of treatment/ Vase life of control)
Immersion for 10 minutes		
BAP (25 µM)	19.13 ± 1.95 c	1.05
BAP (50 µM)	19.73 ± 1.63 c	1.08
BAP (100 µM)	19.39 ± 1.35 c	1.06
GA ₃ (50 µM)	16.66 ± 1.25 d	0.91
GA ₃ (100 µM)	14.53 ± 1.32 e	0.79
GA ₃ (250 µM)	13.67 ± 1.64 e	0.75
Pulsing for 24 hours		
BAP (25 µM)	30.94 ± 2.45 a	1.69
BAP (50 µM)	30.19 ± 2.35 a	1.65
BAP (100 µM)	24.53 ± 1.95 b	1.34
GA ₃ (50 µM)	16.26 ± 1.45 d	0.89
GA ₃ (100 µM)	11.39 ± 1.32 f	0.62
GA ₃ (250 µM)	10.53 f ± 1.52 f	0.58
Control (De ionized water)	18.33 ± 1.65 c	1.00
LSD	1.62	

*Values in each column followed by the same letter are not significantly different at p=0.05

DISCUSSION

Silver nitrate and STS are the most common forms of silver ions used in prolonging the postharvest life of cut flowers and foliage. Inclusion of silver ions in the vase solutions has shown to prolong the vase life of *Anthurium* (Paull and Goo, 1982), flowers of *Matthiola incana* (Celikel and Reid, 2002), cut tuberose flowers (Hutchinson *et al.*, 2003) and roses (Singh and Tewari, 2002, Elgimabi, 2011). In contrast, application of 1000 ppm AgNO₃ (approx 10 mM silver ions) and 2 mM STS had no effect on the vase life of *D. marginata* 'bi colour' and *D. sanderiana* 'white'. Silver ions prolong the vase life of cut flowers and foliage by acting as potent inhibitors of ethylene action inside plant tissues (Paul and Goo, 1982, Elgimabi, 2011). Ethylene does not appear to play a significant role in the senescence process in cut *Dracaena* foliage. The findings of this study are in agreement with Van Doorn *et al.*, (2011) where ethylene has not shown any effect on tepal abscission in tulips. Plants are classified into 4 groups based on their sensitivity to ethylene and the endogenous production of ethylene; as sensitive plants that produce a high amount of ethylene, sensitive plants that produce a low amount of ethylene, insensitive plants that produce a low amount of ethylene and insensitive plants that produce a high amount of ethylene (Ferrante and Francini, 2006). Thus, it is likely that *D. marginata* 'bi colour' and *D.*

sanderiana 'white' are insensitive to ethylene and therefore, silver ions had no effect on prolonging the vase life of these two species.

Benzylaminopurin at low concentrations (25 µM) improved the vase life of all three *Dracaena* species examined. Cytokinin has shown to increase the vase life of cut ornamental leaves of *Hosta plantiagina* (Skutnik *et al.*, 1999), anthuriums (Paul and Goo, 1982), *Heliconia psittacorum* cv 'Andromeda' (Paull and Chantrachit, 2001), cut flowers of *Alstromaria* (Dai and Paul, 1991) and *Tuberose* (Hutchinson *et al.*, 2003). Cytokinins are known to retard senescence of detached leaves and flowers by delaying proteolysis and chlorophyll degradation (Gan and Amasino, 1997; Winger *et al.*, 1998). The loss of decorative value observed in *Dracaena* leaves could be mainly attributed to changes in colour. Thus delayed senescence of cut *Dracaena* leaves may have resulted from BAP-mediated delay in chlorophyll degradation.

Reduction in the postharvest life of *D. Deremensis* with the application of GA₃, is in agreement with Cywinska-Smoter *et al.*, (1978) who reported a decrease the longevity and flower and leaf discoloration in carnation and with (Garibaldi and Deamborgia (1988), who showed that gibberellins have no effect on vase life of *Chrysanthemum* Doi and Reid, (1995) with hybrid *Limonium* and Hutchinson *et al.*, (2003) with cut Tuberose flowers. In contrast to the findings of the present study, Gibberellins (GA₃) had shown to delay leaf yellowing in

Alstroemeria (Dai and Paull, 1991; Muti *et al.*, 2006) and in Easter Lily (Han, 1995; Han, 1997; Ranwala and Miller 1999; Ranwala *et al.*, 2003). These indicate that the plant growth regulators have variable effects on the postharvest quality of different plant species (Bosse and Van Staden, 1989). It is not known what causes the variable effects of gibberellins. One possibility is that exogenous application of synthetic plant growth regulators may alter the natural equilibrium of endogenous growth regulators inducing a stress depending on the plant species and the organ under investigation (Ferrante and Francini, 2006).

Results of the present study suggest that the application of BAP retarded senescence and prolong the vase life of cut foliage of of *D. marginata* 'bi colour', *D. sanderiana* 'white' and *D. deremensis*. Pulsing with 25 µM BAP for 24 h can be recommended as a postharvest treatment to preserve the postharvest quality of cut foliage of of *D. marginata* 'bi colour', *D. sanderiana* 'white' and *D. deremensis* during the marketing process.

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