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Effects of Cold Storage and Different Pulsing Treatments on Postharvest Quality of Cut OT Lily 'Mantissa' Flowers

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Effects of the pulsing solution containing silver thiosulphate (STS) or spermidine on postharvest quality of cut OT Lily 'Mantissa' (an Oriental x Trumpet hybrid) flowers were investigated. The application of spermidine prolonged the inflorescence longevity and improved the quality of cut flower of OT Lily 'Mantissa' in the same way as the STS treatment. The pulsing treatments reduced water dissipation, maintained membrane structure and function, and delayed the accumulation of malondialdehyde (MDA) and proline. The results indicate that spermidine can be used as a commercial preservation solution for cut lilies. Cold treatment reduced the vase life and lowered the quality of cut flower. The pulsing treatment containing anti–ethylene improved the postharvest quality, and the cold–stored cut flowers showed more improvements in the postharveat quality than the cut flowers without cold storage.

INTRODUCTION

OT lily (an Oriental x Trumpet hybrid), in comparison with Oriental lily, has bigger flower buds, longer stems, and stronger disease resistance. 'Mantissa', an OT Lily cultivar, is getting popular in the Chinese market. In circulation, however, there are still some preservation problems that cause financial losses up to 40%. Postharvest treatments with various pulsing solutions have been applied to prolong the vase life of cut lilies, but the studies have been focused on the cultivars of *Lilium longiflorum*, Asiatic and Oriental hybrid lilies (Han, 2001, Nowak and Mynett, 1985; Ranwala and Miller, 2000). Effects of pulsing treatment on the postharvest quality of OT hybrid lily cultivars have not been reported.

Ethylene has been associated with the abscission and leaf chlorosis of cut stems. Silver thiosulphate (STS), a conventional cut–flower preservative, can interact with the ethylene receptor and delay the aging of cut flowers. Now STS has been widely applied in various types of cut flowers and proved to be effective in prolonging the vase life and enhancing the quality of cut flower.

Polyamine acts with the ethylene precursor, adenosine methionine, and hinder the synthesis of ethylene. Anti–senescence properties of polyamines in leaves, flowers and fruits are well documented (Kaur–Sawhney and Galston, 1991; Tachibana, 2000). It has been clarified that endogenous poliamine levels in the petals of cut carnation are related to senescence (Roberts *et al*., 1984; Serrano *et al*., 1991). Effects of spermidine, a polyamine, N–(3–aminopropyl)butane–1,4–diamine, on stimulating postharvest quality of carnation are well known (Luo *et al*., 2003). Bagni and Tassoni (2006) reported that the greatest delay of senescence was evidenced with 10 mM spermidine in the watering solution in cut carnation 'Reiko', and the best results were obtained with 0.1 mM spray and with 10 mM supplied in the watering solution in gerbera 'Lisa'. In rose cut flowers, however, it is reported by Nada *et al*. (2006) that cut flowers of rose 'Noblesse' kept in 0.1 mM spermidine withered earlier than those in distilled water. Application of polyamine on cut lilies has not been reported. In this paper we investigated the effects of pulsing solution containing silver thiosulphate (STS) or spermidine on the longevity of cut OT Lily 'Mantissa' flowers.

There are some reports that ethylene produced by cut lilies during postharvest was very little or was hardly detected, and the effects of exogenous ethylene and ethylene inhibitors on the quality of cut flowers and vase life were not significant (Woltering and van Doorn, 1988; Elgar, 1999). However, other reports indicated that the response to the exogenous ethylene application was sensitive and ethylene treatment reduced the longevity of cut lilies (Nowak and Mynett, 1985; van der Meulen–Muisers and van Oeveren, 1990; Jones and Moody, 1993). There are no common conclusions on ethylene metabolism in cut–flower lilies so far. Cut flowers are normally kept cooled during transportation and marketing. Low temperature reduces metabolic activities to keep cut flowers fresh. On the other hand, it may be a stress that induces ethylene production to stimulate the aging of cut flowers. We, therefore, also investigated the effects of cold storage on the response to the pulsing treatment containing spemidine or STS.

MATERIALS AND METHODS

An OT hybrid lily cultivar 'Mantissa' was used in this study. Stems with only flower buds were cut from a commercial greenhouse at the harvest season. They

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Table 1. Composition of pulsing solutions

Abbreviation	Composition of pulsing solutions
PS1	Water (control)
PS2	30 g/L Sucrose+200 mg/L 8–HQ+100 mg/L GA_3
PS3	30 g/L Sucrose+200 mg/L 8–HQ+100 mg/L GA_3+1.0 nmol/L STS
PS4	30 g/L Sucrose+200 mg/L 8–HQ+100 mg/L GA_3+1.0 nmol/L spermidine

were re–cut to the length of 30 cm with only three leaves remained at the top of the stem before the pulsing treatment.

The stems were placed in glass jars containing various pretreatment solutions (Table 1) and lower 12 cm of the stems were in the pretreatment solutions. The pulsing treatments were carried out for 18 hours at room temperature. After the treatments, a set of cut flowers was transferred to a postharvest evaluation room (day 21 °C/night 14 °C, humidity 60%, fluorescent light 12 hrs/day). Another set of cut flowers was held in distilled water at 4 °C for two weeks in darkness before transferred to the postharvest evaluation room. In the evaluation room, the stems were placed in glass jars containing 500 ml of distilled water, which was 12 cm in height.

During the postharvest evaluation, the number of chlorotic or senescent leaves and the inflorescence longevity were recorded every day. The fresh weight of 10 cut stems was determined every other day. Decrease in fresh weight (%) was calculated by the formula of [(fresh weight of the present day – fresh weight of the first day)/fresh weight of the first day] × 100%.

Relative electrical conductivity and contents of proline and malondialdehyde (MDA) in the inner perianths (0.3 g/sample) of three flowers after removing their midribs were measured every other day. The relative electrical conductivity was measured with electric conductivity meter. The samples for the determination of proline and MDA were stored at −80 °C until analysis. For the determination of MDA, the sample was ground on ice in phosphate buffer (pH7.8, 0.05 mM) and then centrifuged (4 °C, 6000 rpm for 15 min.). The supernatant was used to determine MDA content with thiobarbituric acid (TBA) under high temperature: MDA reacts with TBA and generates 3,5,5,–Trimethyloxazolidine–2,4–dione, which has specific absorbance at 600, 532 and 450 nm. Proline was also determined by the specific colorimetric method at 515 nm, which measures the red and stable product from reaction of praline and hydrindantin dehydrate under acidic condition. Three replicates were performed for all measurements. The experiments were repeated twice.

RESULTS

Effects of pulsing treatments and cold storage on vase life and the quality of cut flowers

An average vase life in water (control, PS1) was 10 days without cold storage after the pulsing treatment (Table 2). The treatment with sucrose and GA_3 (PS2) prolonged about 2 days of the vase life, and those with STS (PS3) and spermidine (PS4) increased the vase life even longer than PS2. They prolonged the period of bud opening. Comparatively, cold storage shortened the vase life in all the treatment conditions. STS treatment

Table 2. Effects of cold storage and solutions on vase life

Cold storage	Pre–treatment solution	Vase life (days)
No	PS1	10.3±0.82[z]
	PS2	11.9±1.6
	PS3	14.7±1.6
	PS4	13.2±1.0
Yes	PS1	6.3±0.5
	PS2	9.5±1.3
	PS3	11.1±0.6
	PS4	9.5±1.3

[z] Values ± standard deviation.

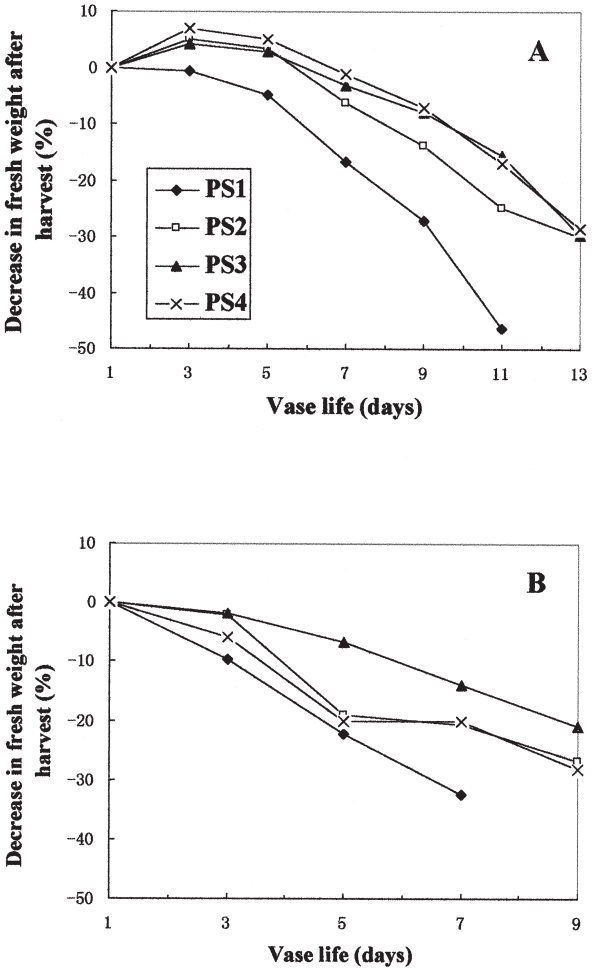

Fig. 1. Effect of different pulsing treatments and cold storage on fresh weight of cut stems (A: cut stems without cold storage, B: cold–stored cut stems).

(PS3) prolonged the vase life longer than spermidine (PS4) after cold storage. Leaf yellowing was not observed regardless of the treatment during the experiments (data not shown).

Effects of pulsing treatments and cold storage on fresh weight

Figure 1A shows the changes of fresh weight of cut stems without cold storage after the pulsing treatments. The fresh weight of control stems (PS1) began to decrease from the third day, but those treated with the pulsing solutions (PS2, PS3 and PS4) slightly increased until day 3 and then slowly decreased. These indicate that STS and spermidine slowed down the weight loss of the cut stems. The fresh weight of all cold–stored cut stems decreased in the postharvest room, but the pulsing treatments, particularly PS3 containing STS, prevented the stems from losing the weight (Fig. 1B).

Effects of pulsing treatments and cold storage on relative electrical conductivity of petals

The electrical conductivity of the petals from the cut stems without cold storage increased slowly along with the aging of cut flowers and there was no significant difference between the treatments (Fig. 2A). Cold storage made the electrical conductivity of the petals increase rapidly from day 5 in the postharvest room (Fig. 2B). The pulsing treatments (PS2, PS3 and PS4) inhibited the increase of the electrical conductivity. These results imply that the pulsing treatments maintained membrane structure and function of the petals and delayed the aging. No significant differences in the electrical conductivity were observed between the different pulsing solutions.

Effects of pulsing treatments and cold storage on the content of proline and MDA

Proline, an effective osmotic adjustment substance, exhibits the water stress level of the plants. As shown in Figs. 3A and 3B, proline content gradually increased along with the opening and aging of the cut flowers without cold storage. There were no big differences in the proline content in the petals among the treatments without cold storage (Fig. 3A). The content of proline in PS1 and PS2 increased just before the aging of cut flowers, whereas the pulsing treatment with STS (PS3) and spermidine (PS4) supressed the increase of proline. Very differently as shown in Fig. 3B from in Fig. 3A, cold storage greatly induced the increase of proline content in PS1. The pulsing treatments, however,

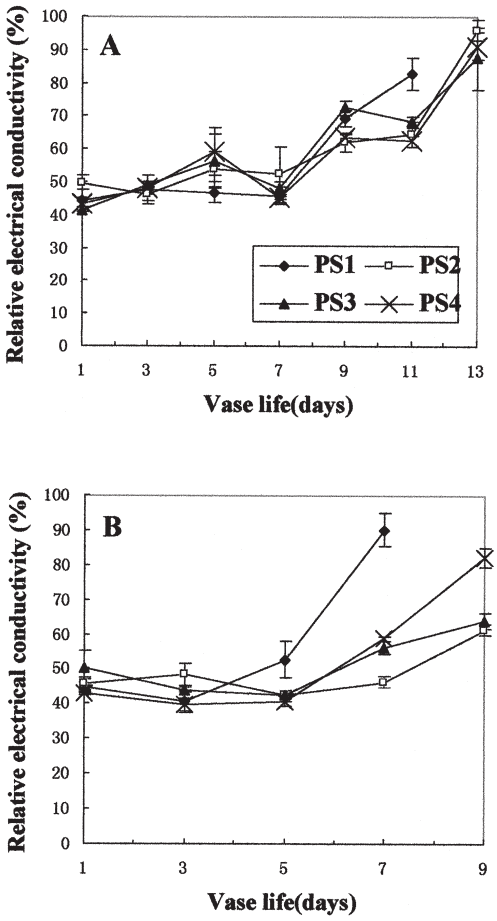

Fig. 2. Effects of different pulsing treatments and cold storage on relative electrical conductivity of the petals (A: Cut stems placed directly in the postharvest room, B: cold–stored cut stems).

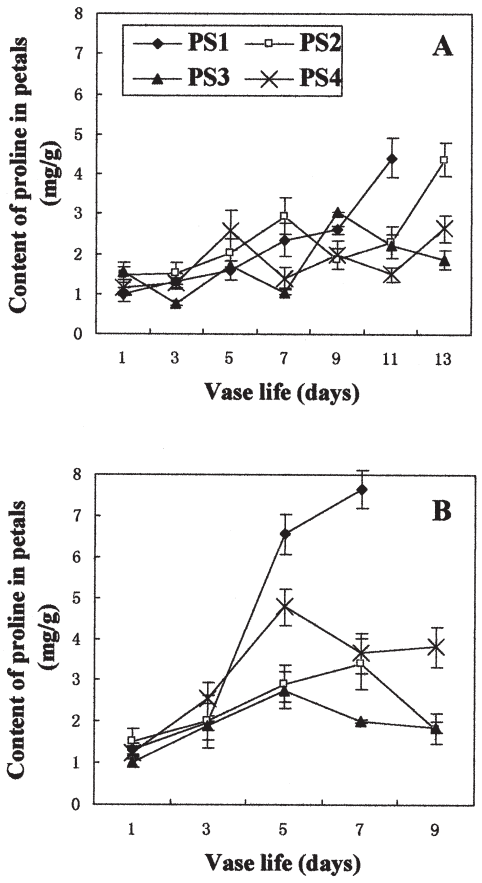

Fig. 3. Effects of different pulsing treatments and cold storage on the content of proline in the petals (A: Cut stems placed directly in the postharvest room, B: cold–stored cut stems).

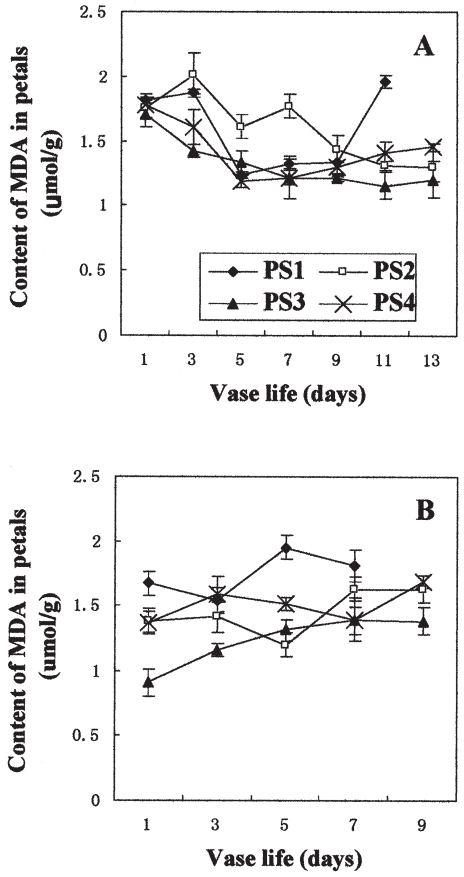

Fig. 4. Effects of different pulsing treatments and cold storage on the content of MDA in the petals (A: Cut stems placed directly in the postharvest room, B: cold stored cut stems).

reduced the accumulation of proline. The effects of STS application were more significant than those of spermidine.

MDA is one of the products from lipid peroxidation. The accumulation of MDA exacerbates the damage of plasma membrane and also reflects the lipid peroxidation level. MDA is commonly used as an indicator in the aging and resistance physiology. The application of ethylene inhibitors without cold storage reduced the accumulation of MDA (Fig. 4A). The content of MDA remained relatively stable from the fifth day to the aging of cut flowers, whereas that in the control petals (PS1) was not. The petals from the cut stems treated with solution containing sucrose and GA3 (PS2) was not stable and was much higher than others. For cold–treated stems (Fig. 4B), the MDA content in the petals of the control (PS1) slightly increased until day 5 followed by a decrease. The pulsing treatment with STS (PS3) effectively inhibited the accumulation of MDA.

DISCUSSION

Three pulsing solutions were used to investigate their effects on postharvest quality of cut OT Lily 'Mantissa' flowers. Sucrose as an energy source is used as a fixed component of the preservative solution, which is applied in all types of fresh cut flowers with a number of fungicides such as 8–HQ (Nowak and Mynett, 1985). GA can effectively delay the aging process, improve the quality of cut flowers and prevent the leaf from yellowing (Han, 2001; Ranwala and Miller, 2000, 2002; Whitman *et al.*, 2001). The chlorotic or senescent leaves were hardly observed in the cut stems with and without cold storage, probably because 'Mantissa' is a new cultivar, which has better resistance to preservation. The pulsing treatment only containing sucrose, 8–HQ and GA_3 prolonged the inflorescence longevity, decreased the loss of water and reduced the damage of cell membrane.

It has been reported that spermidine has the stimulated effects on the preservation of carnation (Luo *et al.*, 2003; Bagni and Tassoni, 2006) and gerbera (Bagni and Tassoni, 2006). In this study spermidine prolonged the inflorescence longevity, decreased the accumulation of proline and MDA, and promoted the postharvest quality of cut flowers. Spermidine, therefore, can be used as a commercial preservation solution for cut lilies although its effects are not as significant as STS in this study. The impact of spermidine on the quality of cut flowers is also related to the application time and the concentration of the solution, which are not included in this study.

Cold storage shortened the inflorescence longevity and decreased the quality of cut flowers. Some physiological indexes indicated that cold storage induced the water dissipation, lipid peroxidation of cell membrane and the accumulation of MDA and proline. The pulsing treatment with ethylene inhibitors reduced the physiological stress caused by cold storage and prolonged the inflorescence longevity. Although the application of ethylene inhibitors promoted the preservative quality of the cut stems without cold storage, the responses of cold stored cut stems were more sensitive to that of the application of ethylene inhibitors. This may be related to the increase of sensitivity to ethylene under cold stress. Han and Miller (2003) reported that cut lilies became sensitive to ethylene when the cut stems harvested earlier or stored at low temperature. The results in our study indicated also the effects of the application of anti–C_2H_4 were more significant and the pulsing treatment containing anti–C_2H_4 under cold storage prolonged the vase life and promoted the postharvest quality.

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