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Effects of Silver Nitrate and Silver Thiosulfate on Vase-Life of Cut Roses

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ABSTRACT

Silver nitrate ($AgNO_3$) ranging in concentrations from 10 to 50 mg l^{-1}, together with 5% sucrose as holding solution significantly increased the vase-life of 'Christian Dior' cut roses; the optimum concentration of $AgNO_3$ was 20 mg l^{-1}. The holding solution containing 5% sucroce + 20 mg l^{-1} $AgNO_3$ also significantly increased the vase-life of rose cultivars 'Eiffel Tower', 'Swartmore' and 'Yankee' but not 'King's Ransom' and 'Confidence'. $AgNO_3$ slightly reduced ethylene production of 'Christain Dior' flowers held in distilled water. $AgNO_3$ greatly reduced ethylene production of flowers in solution containing 1-aminocyclopropane-1-carboxylic acid (ACC); $AgNO_3$ also counteracted the effect of ethylene action induced by ACC. $AgNO_3$ greatly reduced microbial population in vase-water and improved water uptake of 'Chirstian Dior' flowers. Silver thiousulfate (STS) complex was not as effective as $AgNO_3$ for the increase in vase-life of cut roses and the reduction of microbial population.

Key words : cut rose, ethylene, microbial population, silver nitrate, silver thiosulfate, vase-life

INTRODUCTION

Senescence of rose flowers is associated with increased production of ethylene; ethylene brings about changes in membrane physical properties and permeability (Mayak and Halvey, 1972; Faragher and Mayak, 1984; Faragher *et al.*, 1987 a). Farahger *et al.* (1987 b) reported that there was a climacteric in petal ethylene production, a parallel increase ACC content, but a continuous decrease in ethylene forming enzyme activity during rose ageing at 20°C. Aminooxyacetic acid (AOA), silver thiosulfate, sodium benzoate (SB) and rhizobitoxine analog, L-2-amino-4-(2-aminoethoxy)-trans-3-butenoic acid (RO) are very effective inhibitors of ethylene synthesis (Wang, 1977; Baker *et al.*, 1977; Veen, 1979; Yu *et al.*, 1979) but are ineffective in improving the vase life of unstored rose flowers (Wang and Baker, 1979; De Stigter, 1980; Zieslin, 1989). AOA, SB and RO greatly reduce ethylene production in rose petals (Wang and Baker, 1979; Faragher and Mayak, 1984).

Independent of the effects of ethylene, vase-life of cut rose flowers is affected by the development of stem resistance to water on stem plugging. A number of factors have been attributed to the plugging of rose stem and the consequent reduction of water uptake : (1) microbial contamination (Aarts, 1957: Burdett, 1970); (2) organic occlusions or metabolic or microbial origin (Burdett. 1870; Parups and Molnar, 1972; (3) air embolism of the vascular system (Dixon and Peterson, 1989) and (4) uptake of toxic compounds leaking from the stems and leaves (Buys, 1969). The use of bactericides with their resulting reduction of the microbial population, improves the water balance, inhibits senescence and prolongs the vase-life of rose flowers (Marousky, 1969; Burdett, 1970; Van Doorn and Perik, 1990).

The purpose of this study was to investigate the

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role of $AgNO_3$ in prolonging the vase-life of unstored rose flowers.

MATERIALS AND METHODS

The study comprised a series of 6 individual experiments :

Expt 1. Examination of the effect on vase-life of various concentrations of $AgNO_3$ using cultivar 'Christian Dior'.

Expt 2. Examination of the effect of STS using optimum concentration of $AgNO_3$ obtained from Expt 1. The concentrations of $Na_2S_2O_3$ were 1,2,3,4,5 and 6 times (mM) of $AgNO_3$ using cultivar 'Christian Dior'.

Expt 3. Examination of the effect on water uptake of silver in the form of $AgNO_3$ and STS using the concentrations of $AgNO_3$ and STS and rose cultivar as the same in Expt 2.

Expt 4. Examination of the effect of $AgNO_3$ and STS on vase-life using the optimum concentration obtained from Expt 3 for the rose cultivars 'King's Ransom', 'Eiffel Tower', 'Swartmore', Confidence' and 'Yankee'.

Expt 5. Examination of the effects on vase-life, ethylene production and water uptake of ACC and $AgNO_3$ or STS using the optimum concentration of $AgNO_3$ or STS $AgNO_3$ or STS using the optimum concentration of $AgNO_3$ or STS obtained from Expt 2 by using cultivar 'Christian Dior'.

Expt 6. Examination of the effect on microbial population of $AgNO_3$ and STS using the optimum concentration of $AgNO_3$ from Expt 1 and of STS from Expt 2.

Plant material.- For each experiment cut rose flowers were obtained from a commercial grower near Bangkok, Thailand. The flowers were kept dry after cutting and immediately brought to the laboratory. All but the top two compound leaves were removed and the stems were recut at an angle, 30 cm from the calyx. The flowers were then placed individually in 50-ml graduated cylinders containing distilled water (control) or the treatment solutions.

Meassurements

i. **Determination of water uptake.-** Each treatment cylinder contained 50 ml of either distilled water of chemicals. At daily intervals, the difference between consecutive measurements of the cylinder plus distilled water or chemicals (without the flower) was used as the measure of water uptake. Evaporation of water from the surface of the solution amounted between 0.03-0.05 ml/day; evaporative water loss in the experiment was negligible.

ii. **Determination of ethylene production.-** Three weighed roses held in distilled water or the chemical treatments were placed in empty, air-tight, 4240-ml glass bottles fitted with gas sampling ports. At daily intervals, the glass bottle was sealed for three hours and 1-ml gas samples were withdrawn from the headspace for ethylene determination by gas chromatography (Shimadzu GC-14 A). The amount of ethylene produced by the roses was determined by calibration with an ethylene standard. After each determination, the glass bottles were opened for aeration. Each treatment comprised three bottles.

iii. **Determination of microbial population.-** The number of bacteria in the vase-water holding three cut roses of 'Christain Dior' per container was determined after four days by plating a 1-ml diluted water sample on a standard agar counting plate. After incubation at 30-32°C for 48 hours, the number of colonies was counted. Each treatment comprised three plates.

iv. **Determination of vase-life.-** Appearance of bent neck, wilting of outer petals, or blueing of the petals were considered to mark the end of the useful vase-life of the flowers.

During the study the cut roses were held under natural light for 12 hours per day and at ambient temperature and humidity; mean air temperature and relative humidity were 28.6°C and 82.1%, respectively. The data presented represents the means for 12 roses in each experiment except for ethylene and microbial population determination, for which it is the means are the result of three determinations Duncan's New Mulitiple Range Test (DMRT) was used to compare mean differences.

RESULTS

The vase-life of 'Christian Dior' cut flowers held in sucrose alone or sucrose together with $AgNO_3$ ranged from 10 to 50 mg l^{-1} was increased significantly over the control. The optimum concentration of $AgNO_3$ was 20 mg l^{-1} (Table 1). This concentration was therefore used in the subsequent experiments in the study.

Silver in the form of STS with various ratios of $AgNO_3$: $Na_2S_2O_3$ did not increases the vase-life of 'Christian Dior' cut flowers. In fact, STS with all ratios did not increase the vase-life of cut flowers longer than those held in $AgNO_3$ (Table2). Water uptake of 'Christian Dior' held in distilled water was greater in the first 2 days but thereafter declined more rapidly than those held in 5% sucrose and 20 mg l^{-1} $AgNO_3$ or STS, while rates of water uptake of cut roses held in 5% sucrose and STS were lower than those held and in 5% sucrose and $AgNO_3$ throughout the study period (Figure 1).

When flowers of six cutlivars were compared, the addition of $AgNO_3$ more than doubled vase-life of 'Swartmore', 'Yankee' and 'Christian Dior' and significantly increased for 'Eiffel Tower'. However, the treatment did not improve the vase-life of flowers of the cultivars 'King's Ransom' and 'Confidence' (Table 3).

Exogenous application of ACC reduced by a almost half the vase-life of 'Christian Dior' flowers heldin distilledwater; however the addition of$AgNO_3$ completely prevented this reduction of vase-life (Table

Table 1 **Vase-life of 'Christian Dior' cut roses held in holding solutions containing sucrose and various concentrations of $AgNO_3$.**

Holding solution	Vase-life (days)[1]
Distilled Water	4.3 c
5 % sucrose	5.1 b
5 % sucrose + 10 mg l^{-1} $AgNO_3$	7.7 a
5 % sucrose + 20 mg l^{-1} $AgNO_3$	8.0 a
5 % sucrose + 30 mg l^{-1} $AgNO_3$	7.8 a
5 % sucrose + 40 mg l^{-1} $AgNO_3$	7.2 a
5 % sucrose + 50 mg l^{-1} $AgNO_3$	7.3 a
CV (%)	18.2

[1] Mean separation with DMRT at $P = 0.05$

Table 2 **Vase-life of 'Christian Dior' cut roses held in hdding solutions containing silver in the form of $AgNO_3$ or STS at various ratio of $AgNO_3$: $Na_2S_2O_3$.**

Holding solution	Vase-life (days)[1]
Distilled Water	3.5 c
5 % sucrose + 20 mg l^{-1} $AgNO_3$	7.0 a
5 % sucrose + 20 mg l^{-1} STS-ratio 1:1 mM	5.0 b
5 % sucrose + 20 mg l^{-1} STS-ratio 1:2 mM	4.9 b
5 % sucrose + 20 mg l^{-1} STS-ratio 1:3 mM	4.4 bc
5 % sucrose + 20 mg l^{-1} STS-ratio 1:4 mM	5.1 b
5 % sucrose + 20 mg l^{-1} STS-ratio 1:5 mM	4.5 bc
5 % sucrose + 20 mg l^{-1} STS-ratio 1:6 mM	5.1 b
CV (%)	28.9

[1] Mean separation with DMRT at $P = 0.05$.

Table 3 **Vase-life of different cultivars of cut roses held in distilled water (control) and holding solution containing 5 % sucrose + 20 mg l^{-1} $AgNO_3$.**

Cultivar	Vase-life (days)[1]
'Christian Dior'	
control	3.5 ef
5 % sucrose + 20 mg l^{-1} $AgNO_3$	7.5 e
'King's Ransom'	
control	1.3 g
5 % sucrose + 20 mg l^{-1} $AgNO_3$	1.1 g
'Eiffel Tower'	
control	2.8 f
5 % sucrosc + 20 mg l^{-1} $AgNO_3$	5.2 d
'Swartmore'	
control	4.0 e
5 % sucrose + 20 mg l^{-1} $AgNO_3$	10.2 a
'Confidence'	
control	3.5 ef
5 % sucrose + 20 mg l^{-1} $AgNO_3$	4.4 de
'Yankee'	
control	4.0 e
5 % sucrose + 20 mg l^{-1} $AgNO_3$	9.0 b
CV (%)	23.3

[1] Mean separation with DMRT at $P = 0.05$

Table 4 **Vase-life of 'Christian Dior' cut roses held in different holding solutions.**

Holding solution	Vase-life (days)[1]
Distilled Water	3.4 b
50 mg l^{-1} ACC	1.9 c
5 % sucrose + 20 mg l^{-1} $AgNO_3$	5.2 a
5 % sucrose + 50 mg l^{-1} ACC + 20 mg l^{-1} $AgNO_3$	4.7 a
CV (%)	19.3

[1] Mean separation with DMRT at $P = 0.05$

4). Exogenous application of ACC caused rapid wilting and darkening of petals, while $AgNO_3$ completely counteracted these symptoms (Figure 2).

Exogensous application of ACC greatly stimulated ethylene production of flowers of 'Christian Dior' reaching a maximum after 1 day and thereafter showing a decline (Figure 3). $AgNO_3$ greatly reduced ethylene production of flowers held in solution containing ACC. The rate of ethylene production of flowers held in solution containing no ACC but to which $AgNO_3$ was added, was little different to the control.

Water uptake of 'Christian Dior' flowers held in distilled water and ACC solution declined rapidly, with the decline in ACC solution alone being more

Table 5 **Bacteria levels in vase-water containing different treatments at day 4 for 'Christian Dior' cut roses.**

Chemical	Bacteria count (colonies/ml)
Distilled Water	1.03×10^6 -1.42×10^8
5 % sucrose	2.83×10^7 -2.10×10^8
5 % sucrose + 20 mg l^{-1} $AgNO_3$	non-detected-<101
5 % sucrose + 20 mg l^{-1} STS (1:4 mM)	$<10^2$ -1.76×10^6

rapid than in distilled water alone (Figure 4). Rates of water uptake of cut flowers held in solutions containing 5% sucrose plus 20 mg l^{-1} $AgNO_3$, Greater than that for flowers held in either distilled water or ACC solution alone (Figure 5).

The bacterial count in vase-water containing 5% sucrose was greater than that of distilled water. STS plus 5% sucrose had less effective in reducing the number of bacteria, while $AgNO_3$ plus 5% sucrose reduced considerably the number of bacteria in vase-water (Table 5).

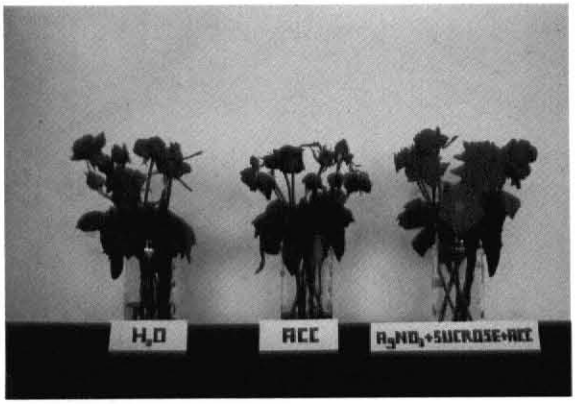

Figure 2 Appearance of 'Christain Dior' cut roses held in distilled water, 50 mg l^{-1} ACC and 5 % sucrose + 20 mg l^{-1} $AgNO_3$ + 50 mg l^{-1} ACC for 4 days at ambient temperature.

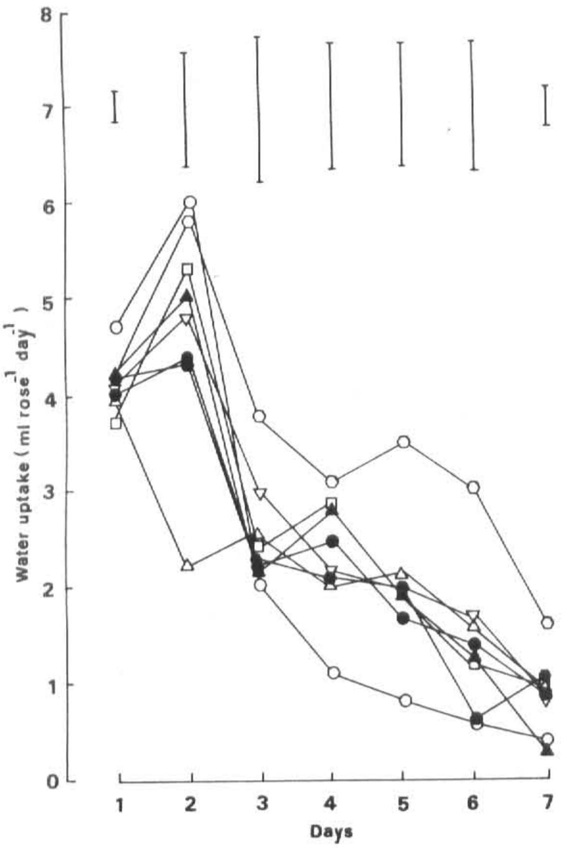

Figure 1 Rates of water uptake of 'Christian Dior' cut roses held in solutions containing distilled water (○), 5 % sucrose + 20 mg l^{-1} $AgNO_3$ (⬡), 5 % sucrose + 20 mg l^{-1} STS - 1:1 mM (⬢), 5 % sucrose + 20 mg l^{-1} STS - 1:2 mM (△), 5 % sucrose + 20 mg l^{-1} STS - 1:3 mM (▲), 5 % sucrose + 20 mg l^{-1} STS - 1:4 mM (▽), 5 % sucrose + 20 mg l^{-1} STS - 1:5 mM (□)and 5 % sucrose + 20 mg l^{-1} STS - 1:6 mM (●). The vertical bars represent the standard error of the means.

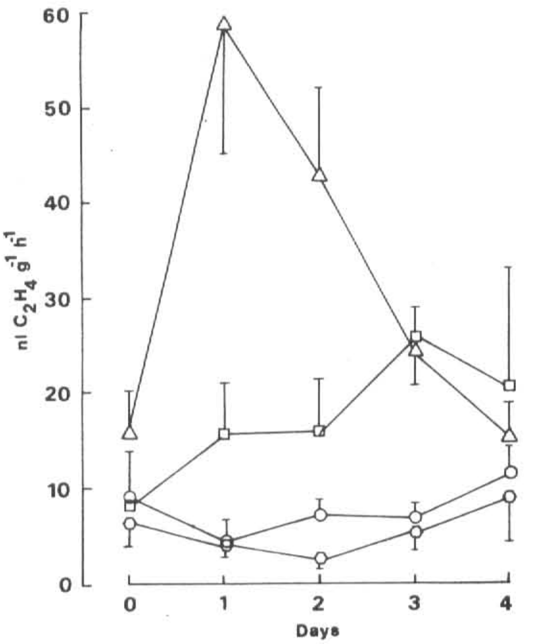

Figure 3 Rates of ethylene production of 'Christian Dior' cut roses held in solutions containing distilled water (○), 50 mg l^{-1} ACC(△) 5 % sucrose + 20 mg l^{-1} $AgNO_3$ (⬡) and 5 % sucrose + 20 mg l^{-1} $AgNO_3$ + 50 mg l^{-1} ACC (□). The vertical bars represent the standard error of the means.

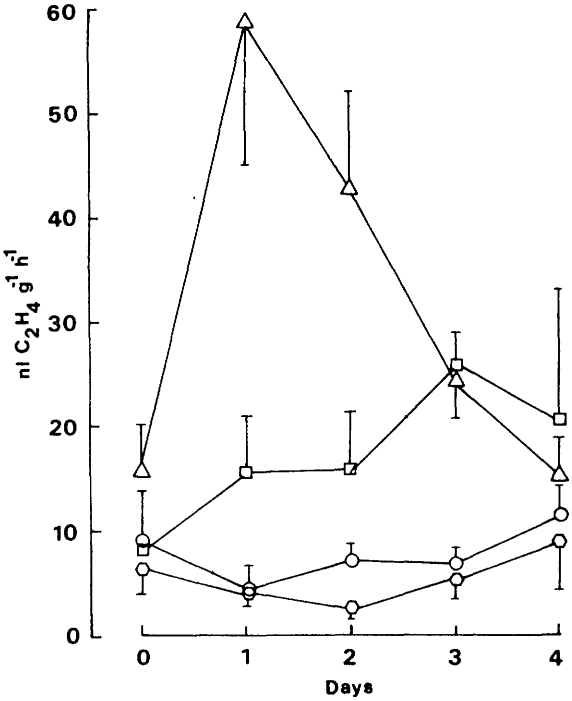

Figure 4 Rates of water uptake of 'Christian Dior' cut roses held in solutions containing distilled water (○), 50 mg l^{-1} ACC (△)), 5 % sucrose + 20 mg l^{-1} $AgNO_3$ (⬡) and 5 % sucrose + 20 mg l^{-1} $AgNO_3$ + 50 mg l^{-1} ACC (□). The vertical bars represent the standard error of the means.

DISCUSSION

The results of the study clearly showed that $AgNo_3$ is able to increase the vase-life of 'Christian Dior', 'Swartmore' and 'Yankee' flowers. This is consistent with reports of silver being able to increase the vase-life of anthurium (Paull and Goo, 1982), carnations (Mayak *et al.*, 1977), gerberas (Van Metereen, 1978) and sweet peas (Mor *et al.*, 1981). The role of silver in prolonging the vase-life of cut flowers as mentioned is understood to be as a bactericide. Silver has also been reported to reduce ethylene production of carnations resulted in prolonging their vase-life (Veen, 1979). Rose flowers do not produce measurable ethylene during their entire life (Faragher *et al.*, 1987 b) and $AgNO_3$ redued slightly the rates of ethylene production of 'Christian Dior' flowers obtained in this study suggest that endogenous ethylene may not be involved in controlling the postharvest life of 'Christian Dior' flowers, unless it is present as an atmospheric pollutant (Reid *et al.*, 1989) or when its synthesis is stimulated by stress (Faragher *et al.*, 1987 b). Though STS is more mobile than $AgNO_3$ (Novak and Vacharotayan, 1980) but the slight reduction in the rate of ethylene production of 'Christian Dior' flowers should not be due to immobility of $AgNO_3$ beacuse $AgNO_3$ treatment reduced considerable ethylene production in the presence of ACC. $AgNO_3$ treatment also prevented effectively the effect of ethylene action induced by exogenous application of ACC. This was similar to the result obtained by De Stigter (1980). The reduction in ethylene production of 'Christian Dior' flowers with and without ACC by $AgNO_3$ treatment may be due to its inhibitory effect on the ACC conversion to ethylene (Philosoph-Hadas *et al.*, 1985). Cut roses used in this study had intact leaves. Most of ethylene produced by cut roses with and without ACC may come from leaves beacuse leaves of cut roses have the most capacity to produce ethylene (Trakooldit, 1989).

Microbial contamination has been shown to be one of the factors involved in plugging of rose stems (Marousky, 1969; Van Doorn and Perik, 1990). The use of $AgNO_3$ as a bactericide in this study resulted in a significant reduction of the microbial population (Mayak *et al.*, 1977; Van Doorn *et al.*, 1991) and improved the water uptake of 'Christian Dior' flowers. This suggests that $AgNO_3$ may reduce the vascular blockage of cut roses. When silver was applied as STS whose antibacterial property was reduced (Van Doorn *et al.*, 1991) resulting in less water uptake and shortening the vase-life of 'Christian Dior' flowers as compared to $AgNO_3$. Similarly Paull and Goo (1982) reported that STS complex was not as effective as $AgNO_3$ in short pretreatment of stems of anthuriums. It was also apparent from the study that microbial contamination in the vase-water may control the vase-life of unstored 'Christian Dior' flowers rather than ethylene. This was probably the situation in 'Eiffel Tower', 'Swartmore' and 'Yankee' flowers as well. The reason for the $AgNO_3$ treatment not increasing the vase-life of 'Confidence' and 'King's Ransom' flowers will need clarification through further study. This difference in the response of the different rose cultivars suggests its mechanisms for increasing vase-life may involve a number of factors.

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