

Effect of 1-methylcyclopropene (1-MCP) on the vase life of cut carnation,  
*Delphinium* and sweet pea flowers

Kazuo ICHIMURA<sup>1\*</sup>, Hiroko SHIMIZU<sup>1</sup>, Toshihiko HIRAYA<sup>2</sup>  
and Tamotsu HISAMATSU<sup>3</sup>

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### Summary

The effect of 1-methylcyclopropene (1-MCP) on the vase life of cut carnation, *Delphinium* and sweet pea flowers, which are typical ethylene-sensitive flowers, were compared with that of silver thiosulfate complex (STS). Treatment with 1-MCP doubled the vase life of cut carnations, and significantly extended the vase life of cut *Delphinium*. The effect of 1-MCP, however, was slightly weaker than that of STS in carnations and much weaker than that of STS in *Delphinium*. Treatment with 1-MCP markedly extended the vase life of cut sweet pea as did that with STS.

**Key Words** : carnation, *Delphinium*, ethylene, 1-methylcyclopropene, sweet pea, vase life.

### Introduction

Ethylene is involved in the factors causing senescence of many cut flowers. Carnation and *Delphinium* flowers are sensitive to ethylene (Woltering and van Doorn, 1988; Ichimura et al., 2000). Sweet pea flowers are also considered to be sensitive to ethylene since silver thiosulfate complex (STS), an inhibitor of ethylene action, markedly extends their vase life (Mor et al., 1984). In addition, STS is markedly effective in extending the vase life of many other cut flowers including carnation and *Delphinium* (Veen, 1979; Uda et al., 1997). However, STS contains silver that is a potent environmental pollutant. Therefore, it needs to be replaced by other non-toxic chemicals. Aminooxyacetic acid (AOA) (Broun and Mayak, 1981),  $\alpha$ -aminoisobutyric acid (AIB) (Serrano et al., 1990; Onozaki et al., 1998), aminoethoxyvinyl glycine (AVG) (Baker et al., 1977), and 1,1-dimethyl-4-phenylsulfonylesemicarbazide (DPSS) (Midoh et al., 1996) inhibit ethylene biosynthesis and effectively prolong the vase life of cut carnations. However, AOA and AIB did not extend the vase life of *Delphinium* although AVG and DPSS extended the vase life as much as STS. In addition, all of these compounds did not extend the vase life of cut sweet pea flowers

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Department of Production,

<sup>1</sup>National Institute of Floricultural Science, Ano, Mie 514-2392

<sup>2</sup>Nagano Nanshin Agricultural Experiment Station, Takamori, Nagano 399-3103

<sup>3</sup>Department of Genetics and Physiology, National Institute of Floricultural Science, Ano, Mie 514-2392

\*Corresponding author : E-mail, ichimu@affrc.go.jp

(Uda et al., 1997). Diazocyclopentadiene, an ethylene action inhibitor, somewhat extended the vase life of cut sweet peas, but the effect was less than that of STS (Sexton et al., 1995).

A volatile compound, 1-methylcyclopropene (1-MCP), is an inhibitor of ethylene action. It has been reported that the vase life of various cut flowers, such as carnation and snapdragon, can be extended by exposure to 1-MCP (Serek et al., 1995, Sisler et al., 1996ab). Similarly, the postharvest life of flowers in potted plants including rose and *Begonia* is extended by 1-MCP (Serek et al., 1994). However, in these studies, flowers that had been treated with 1-MCP were exposed to ethylene at a concentration much higher than that of ambient air. In addition, the effect of STS was not investigated in these studies.

In the present study, therefore, we examined the effects of 1-MCP on the vase life of cut carnation, *Delphinium* and sweet pea flowers, which are typical ethylene-sensitive flowers, to clarify whether 1-MCP can be practically useful. We also compared the effect of 1-MCP with that of STS.

## Materials and Methods

### *Plant materials and treatments*

Carnation (*Dianthus caryophyllus*) cv. Nora and *Delphinium* hybrid cv. Bellamosum were grown in a greenhouse of National Institute of Floricultural Science (NIFS; Ano, Mie). Sweet pea (*Lathyrus odoratus* L.) cv. Kristina was grown in a greenhouse of Nagano Nanshin Agricultural Experiment Station (Takamori, Nagano). Carnation flowers were harvested at a normal harvesting stage, that is, the petals were approximately 60° from the vertical. *Delphinium* flowers were harvested when about 70% of the florets opened. These cut flowers were immediately transported to the laboratory at NIFS. Sweet pea flowers were harvested when two florets opened on November, 2000. The cut flowers put in water were transported to the laboratory at NIFS. The laboratory was maintained at 23°C, 70% relative humidity, and 10  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  irradiance, using cool-white fluorescence lamps for a 12-hr photoperiod. Cut carnation, *Delphinium* and sweet pea flowers were trimmed to 40, 40 and 30 cm, respectively, and the cut ends immersed in distilled water or 0.2 mM STS for 4 hr. STS has been found to be the most effective under this condition (Uda, 1996). The cut flowers with the cut ends in distilled water were placed in an acryl-made chamber (70 liters) and then Ethyl Bloc (AgLead K.K., Tokyo) was added to the distilled water to evolve 1-MCP at a concentration of 0.25, 0.5, 1 and 2  $\mu\text{l liter}^{-1}$ . The flowers were exposed to 1-MCP for 4 hr. Distilled water served as the control. These treatments were started within 1 hr after harvest for carnation and *Delphinium* and 5 hr after harvest for sweet pea. After the treatments, each spike was transferred to a test tube containing 10 ml of distilled water.

### *Evaluation of vase life*

The vase life of carnation flowers was considered to have terminated when petals showed in-rolling or necrosis, and that of *Delphinium* flowers, when the sepals of the last floret abscised. The vase life of florets that opened on the day of harvest was regarded as the period from harvest to the time when its sepals abscised. For sweet peas, the vase life of the spikes was regarded as the period from harvest to

the time when the last floret wilted. The vase life of florets which opened before the day of harvest, opened on the day of harvest and unopened at harvest were also determined. The vase life of florets was considered to have terminated when the petals lost their turgor.

### Results

In carnation, the first sign of senescence in the control flowers was petal in-rolling. However, cut carnation flowers treated with 1-MCP did not show petal in-rolling as observed in those treated with STS. Treatment with 1-MCP at 1  $\mu\text{l}\cdot\text{liter}^{-1}$  extended the vase life of cut carnation flowers by 8 days, which was significantly less than that of STS (Table 1). 1-MCP at 0.25, 0.5 and 2  $\mu\text{l}\cdot\text{liter}^{-1}$  extended the vase life of cut carnation flowers as much as that at 1  $\mu\text{l}\cdot\text{liter}^{-1}$  (data not shown).

Treatment with 1-MCP at 1  $\mu\text{l}\cdot\text{liter}^{-1}$  extended the vase life of florets and spikes of cut *Delphinium* by one day, but the effect of 1-MCP was significantly less than that of STS (Table 2). 1-MCP at 0.25, 0.5 and 2  $\mu\text{l}\cdot\text{liter}^{-1}$  extended the vase life of *Delphinium* as much as that at 1  $\mu\text{l}\cdot\text{liter}^{-1}$  (data not shown).

In sweet pea flowers, treatment with 1-MCP extended the vase life of florets that opened before the day of harvest by 3 days. This effect was significantly greater than that of the treatment with STS. Treatment with 1-MCP extended the vase life of florets in other stages and flower spikes as much as that with STS (Table 3, Fig.1).

Table 1. Effects of 1-MCP and STS on the vase life of cut carnation flowers.

Treatment	Vase life (days)
Control	8.2 ± 0.1 a <sup>z</sup>
1-MCP	15.8 ± 0.5 b
STS	20.0 ± 0.9 c

Flowers were treated with 1  $\mu\text{l}\cdot\text{liter}^{-1}$  1-MCP or 0.2 mM STS for 4 hr.

<sup>z</sup>Values are means of 9 replications ± S.E. and those with the same letters are not significantly different (P<0.05) by Fisher's PLSD test.

Table 2. Effects of 1-MCP and STS on the vase life of cut *Delphinium* flowers.

Treatment	Vase life (days)	
	Floret	Spike
Control	5.7 ± 0.2 a <sup>z</sup>	6.1 ± 0.2 a
1-MCP	7.1 ± 0.2 b	7.3 ± 0.3 b
STS	10.2 ± 0.6 c	11.7 ± 0.5 c

Flowers were treated with 1  $\mu\text{l}\cdot\text{liter}^{-1}$  1-MCP or 0.2 mM STS for 4 hr.

<sup>z</sup>Values are means of 9 replications ± S.E. and those with the same letters are not significantly different (P<0.05) by Fisher's PLSD test.

Table 3. Effects of 1-MCP and STS on the vase life of cut sweet pea flowers.

Treatment	Vase life (days)			Spike
	Floret			
	Opened before harvest	Opened on the day of harvest	Unopened at harvest	
Control	3.0 ± 0.2 a <sup>z</sup>	3.4 ± 0.2 a	3.5 ± 0.4 a	6.3 ± 0.7 a
1-MCP	6.4 ± 0.2 c	7.1 ± 0.2 b	6.1 ± 0.5 b	8.5 ± 0.5 b
STS	5.5 ± 0.4 b	6.5 ± 0.5 b	7.3 ± 0.4 b	9.4 ± 0.2 b

Flowers were treated with 1 µl·liter<sup>-1</sup> 1-MCP or 0.2 mM STS for 4 hr.

<sup>z</sup>Values are means of replications ± S.E. and those with the same letters are not significantly different (P<0.05) by Fisher's PLSD test.

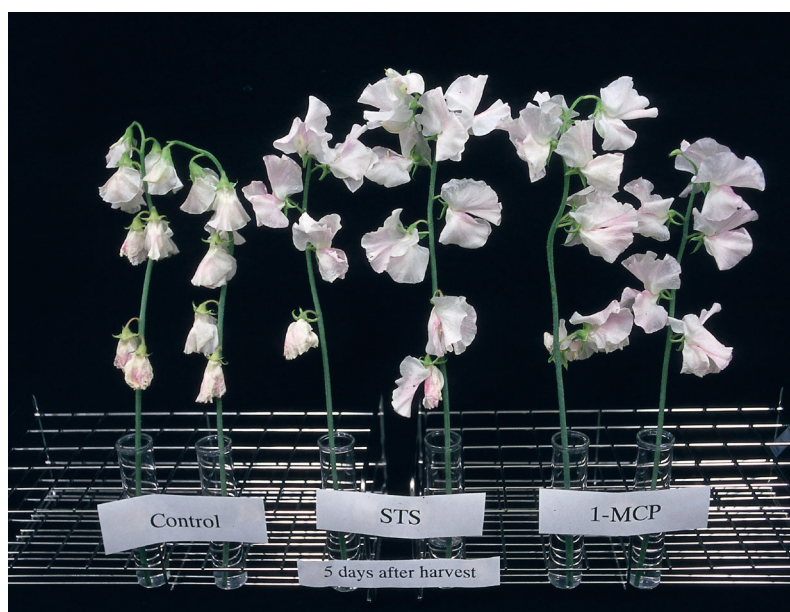


Fig.1. Photographs of flower spikes treated with water (control) (left), 0.2 mM STS (middle), and 1 µl·liter<sup>-1</sup> 1-MCP (right) 5 days after harvest.

## Discussion

In our study, treatment with 1-MCP markedly extended the vase life of carnations and sweet peas. In addition, visible damage was not observed in the cut flowers exposed to 1-MCP at concentrations much higher than those reported by previous studies (Serek et al., 1995; Sisler et al., 1996ab, 1999). The results suggest that 1-MCP can be practically useful for extending the vase life of cut carnation and sweet pea flowers. In *Delphinium* flowers, however, 1-MCP extended the vase life only slightly, but though

significantly, and this effect was much less than that of STS. Thus, 1-MCP may not be suitable for practical use.

1-MCP is considered to bind to the ethylene receptor irreversibly, resulting in the inhibition of ethylene action (Serek et al., 1995; Sisler et al., 1996ab). However, treatment with 1-MCP extended the vase life of *Delphinium* flowers only slightly (Table 2). In addition, the effect of 1-MCP on the vase life of carnation flowers was not so strong, compared with that of STS (Table 1). Similarly, treatment with 1-MCP did not extend the vase life of native Australian cut flowers, which are sensitive to ethylene (Macnish et al., 2000). In carnation, 1-MCP at higher concentration is required in old flowers than in young flowers to protect them from ethylene action (Sisler et al., 1996a). Furthermore, the expression of genes for ethylene receptors increased with flower senescence in some plants such as tomato (Payton et al., 1996) and pea (Orzaez et al., 1999). These findings suggest that ethylene receptors may be synthesized during flower senescence. In our study, cut flowers were treated with 1-MCP only for 4 hr. Thus, we suppose that ethylene receptors to which 1-MCP bound may be replaced by newly synthesized receptors. The newly synthesized receptors, which can bind ethylene, may lower the effectiveness of 1-MCP on the vase life of carnation and *Delphinium*.

Compared with 1-MCP, STS markedly extended the vase life of carnation and *Delphinium* flowers (Tables 1 and 2). In potted *Pelargonium* flowers, treatment with 1-MCP completely inhibited ethylene-induced petal abscission, but this effect disappeared 4 days after the treatment (Cameron and Reid, 2001). On the contrary, inhibition of petal abscission lasted for longer than 10 days when *Pelargonium* had been treated with STS. *Pelargonium* inflorescences were not visible at the time of treatment with STS (Cameron and Reid, 1983). Furthermore, STS is known to have high mobility in plant (Veen and van de Geijn, 1978) and inhibit ethylene action by binding its receptors (Sisler et al., 1986). Taken together, these findings indicate that STS is freely mobile in the plant over a relatively long period and binds ethylene receptors, which is likely to be responsible for effectiveness of STS.

In cut sweet pea flowers, 1-MCP extended the vase life of florets more than STS at a lower nodal position, but less than STS at an upper nodal position (Table 3). This indicates that 1-MCP is more effective than STS in senesced florets, but not in buds. Ichimura and Hiraya (1999) reported that treatment with sucrose extends the vase life of florets harvested at a bud stage. In addition, sucrose promotes pigmentation of petal colors in some cut flowers such as *Eustoma* (Ichimura and Korenaga, 1998) and sweet pea (Ichimura and Hiraya, 1999) whereas STS accelerates fading of petal colors of cut sweet pea flowers (Watanabe et al., 1999). Thus, combined treatment with 1-MCP and sucrose may be preferable for improving the vase life of cut sweet peas. Further studies are in progress to clarify this postulation.

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## カーネーション，デルフィニウムおよびスイートピー切り花の 品質保持に及ぼす1-メチルシクロプロペン(1-MCP)の影響

市村 一雄・清水 弘子・平谷 敏彦・久松 完

### 和文摘要

カーネーション，デルフィニウムおよびスイートピー切り花の品質保持に及ぼす1-メチルシクロプロペン(1-MCP)処理の影響をチオ硫酸銀錯塩(STS)処理と比較した。1-MCPはカーネーション切り花の花持ちを約2倍に延長したが，その効果はSTSよりやや劣った。1-MCPはデルフィニウム切り花の花持ちを有意に延長したが，その効果はSTSより劣った。それに対して，1-MCPはスイートピー切り花の花持ちをSTSと同等以上に延長した。