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Vase life of *Eustoma grandiflorum* as affected by aluminum sulfate

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Abstract. A floral preservative solution containing aluminum sulfate at 150 mg L^{-1} under 25°C, extended cut eustoma (*Eustoma grandiflorum* Shinn. cv. Hei Hou) vase life. The vase life was about 15 days for cut flowers supplied with aluminum sulfate, whereas the vase life of the water controls was only 8 days. The fresh weight of cut eustoma flowers treated with aluminum sulfate continued to increase up to 8 days after vase treatment, then declined thereafter. By contrast, the fresh weights of cut eustoma flowers in water controls began to reduce at the 6th day after vase treatment. The water loss from cut eustoma flowers treated with aluminum sulfate was lower than that of water controls during vase period, and the reverse was true for water uptake.

Keywords: Aluminum sulfate; Cut flower life; *Eustoma grandiflorum*; Water uptake.

Introduction

Aluminum sulfate $Al_2(SO_4)_3$ treatment has been recommended for maintaining vase life of several cut flowers (De Stigter, 1981; Van Doorn, 1997; Ichimura and Ueyama, 1998). This is based, at least in part, on its action as an antimicrobial agent in the vase solution (Halevy and Mayak, 1981). De Stigter (1981), for example, found that Al^{+3}-treated cut rose flowers attained a better quality than the water controls. In addition, Ichimura and Korenaga (1998) reported the vase life of cut eustoma flowers are greatly improved by sugars and 8-hydroxyquinoline sulfate.

The purpose of this work was twofold: first, to compare the cut eustoma flower quality using different concentrations of aluminum sulfate solution, and second, since the mode of action of aluminum sulfate on cut eustoma quality is not known, we studied water uptake and flower fresh weight during vase life.

Materials and Methods

All experiments were performed with eustoma (*Eustoma grandiflorum* Shinn.) cv. Hei Hou. Cut flower stems (40 cm in length) were placed in an opening solution containing aluminum sulfate at 0, 50, 100 and 150 mg L^{-1} immediately after cutting and were placed in chambers at 25°C. The relative humidity was about 70%. A 12 h photoperiod was maintained using fluorescent lamps (Philips cool-white fluorescent) with a light intensity of 15 µmol m^{-2} s^{-1} PPFD at the top of the corolla. For the vase life study, the rate of flower opening and the length of vase life were measured. Three stages were utilized to characterize the flower opening:

Stage 1, tight bud: the sepals enclosed the floral bud.

Stage 2, blooming: half-open and fully open flowers.

Stage 3, tight floral buds and/or open flowers wilted.

Vase Life Evaluation at Various Concentrations of Aluminum Sulfate

Three cut flowers (each cut stem contained 2-3 flowers) were placed into a 1000-mL flask with 800 mL of solution. The aqueous solutions of aluminum sulfate used in these experiments were: 0, 50, 100 or 150 mg L^{-1}. Distilled water was used for the controls. The vase life of cut flowers was completed when the petals or stem below the flower head lost turgor.

Effect of Aluminum Sulfate at 150 mg L^{-1} on Water Uptake, Fresh Weights and Vase Life of Cut Flowers

The stage of flower opening was recorded daily. The fresh weight of the cut flowers and water uptake were also measured daily. The volume of water uptake was calculated by subtracting the volume of water evaporated from a flask of the same volume without cut flowers. Water loss volume was calculated by subtracting the increase in fresh weight from the water uptake volume.

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Results and Discussion

We found that the vase life of cut eustoma flowers was significantly extended when using 150 mg L^{-1} of aluminum sulfate (Table 1, Figure 1). The vase life was about 15 d for cut flowers supplied with aluminum sulfate solution, whereas the vase life of the water controls was only 8 d. It is well known that bacteria proliferating in the vase water shortens the vase life of cut flowers (Dansereau and Vines, 1975; Mayak et al., 1977; De Stigter, 1981; Zagory and Reid, 1986; Van Doorn et al., 1990; Jones and Hill, 1993). It is also well documented that the most common cause of the termination of vase life in cut flowers is water stress (Jones and Hill, 1993). A variety of germicides has been suggested to prevent the rapid proliferation of microorganisms and a subsequent reduction in cut flower longevity (Van Doorn and Perik, 1990). Despite these results, the response of many cut flowers to germicides is highly variable among species (Fujino et al., 1983). In our study, the beneficial effect of aluminum sulfate at 150 mg L^{-1} may be due partially to its germicidal effect.

There was a significant difference in fresh weights (Figure 2) and water uptake (Figure 3) between cut flowers placed in aluminum sulfate at 150 mg L^{-1} and those in distilled water (Figures 2-3). Moreover, water loss from cut flowers treated with aluminum sulfate was lower than that of water controls (Table 3). The results suggest that transpiration was inhibited by aluminum sulfate (Table 3). These results were in agreement with reports by Van Doorn (1997), who indicated that vascular blockage in water controls caused water deficit, which shortened the vase life. The fresh weight of cut eustoma flowers treated with aluminum sulfate continued to increase up to 8 d after vase treatment, then declined thereafter. The decline in fresh weight on the 8th d was due to flower wilting (Figure 2). This indicates absence of vascular blockage in the aluminum sulfate treated flowers. The results may be explained

Table 1. Effects of concentrations of aluminum sulfate on vase life of eustoma. Values are means of 4 replications ± SD. Vase life denotes days from the beginning of vase treatment to the wilting of the last flower (tight floral buds are included).

Treatment	Vase life (d)
Water control	8.2 ± 0.8
$Al_2(SO_4)_3$ 50 mg L^{-1}	11.3 ± 1.2
$Al_2(SO_4)_3$ 100 mg L^{-1}	12.9 ± 1.5
$Al_2(SO_4)_3$ 150 mg L^{-1}	15.4 ± 1.2

Figure 1. Treatment of aluminum sulfate in the vase solution and vase life of eustoma. A, water controls. The flowers were wilted on the 8th d after vase treatment; B, Aluminum sulfate at 150 mg L^{-1}. The photograph was taken 12 d after vase treatment.

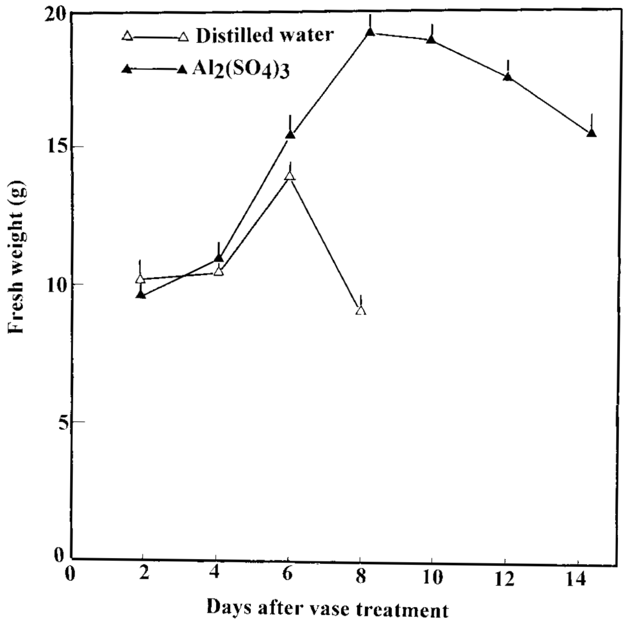

Figure 2. Effect of treatment of aluminum sulfate in vase water on fresh weights of cut eustoma flowers. Vertical bars denote ± SD (n=6).

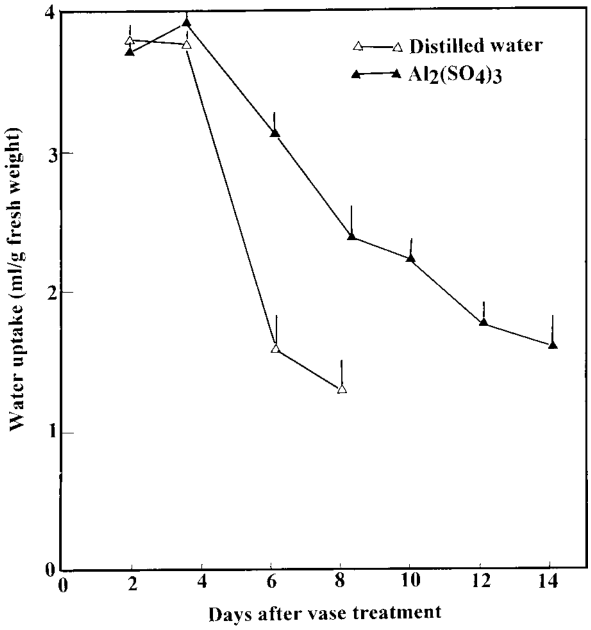

Figure 3. Effect of treatment of aluminum sulfate in vase water on water uptake of cut eustoma flowers. Vertical bars denote ± SD (n=4).

by the fact that cut flowers treated with aluminum sulfate absorbed more water than those in water controls. This allowed more increase in fresh weight which was mostly due to better corolla development (Table 2, Figure 1). Tight floral buds opened almost 100% during the vase period of aluminum sulfate treatment, while very few tight floral buds in water controls fully opened. These tight buds rather wilted prematurely in the water controls (Table 2).

The role of aluminum sulfate in increasing vase life is not limited to lowering the pH in the vase solution. Understanding the initiation of this process could lead to ways of increasing the vase life in cut eustoma flowers. Aluminum sulfate in the vase solution can be applied to a commercial floral preservative for cut eustoma flowers.

Table 3. Effects of aluminum sulfate in vase solution on water loss of cut eustoma flowers. Values are 4 replications ± SD. Volumes of water loss was calculated by subtracting the increase of fresh weight from the volume of water uptake.

Days after treatment	Water loss (g/g•fresh weight)	
	Water controls	Aluminum sulfate
2	3.3 ± 0.3	2.9 ± 0.4
4	5.5 ± 0.3	4.7 ± 0.5
6	6.6 ± 0.6	3.8 ± 0.4
8	6.4 ± 0.4	2.3 ± 0.4
10	-	5.8 ± 0.4
12	-	4.9 ± 0.3
14	-	3.3 ± 0.1

Table 2. Effects of aluminum sulfate treatment at 150 mg L^{-1} on flower opening of cut eustoma. Values are means of 6 replications ± SD. Stage 1, 2 or 3 indicate tight floral buds, half-opened or fully opened flowers, and wilted flowers, respectively.

Days after treatment	Stage 1		Stage 2		Stage 3	
	A[a]	B[b]	A	B	A	B
0	2.3 ± 0.4	2.5 ± 0.2	2.0 ± 0.1	4.1 ± 0.4	0	0
2	2.3 ± 0.4	2.5 ± 0.2	2.0 ± 0.1	4.1 ± 0.4	0	0
4	1.3 ± 0.2	1.3 ± 0.1	2.0 ± 0.2	4.0 ± 0.3	1.0 ± 0.1	1.3 ± 0.1
6	0	1.3 ± 0.1	2.3 ± 0.2	4.0 ± 0.4	2.0 ± 0.2	1.3 ± 0.1
8	0	0	0	3.0 ± 0.2	4.3 ± 0.2	3.6 ± 0.3
10	0	0	0	2.0 ± 0.1	-	4.6 ± 0.2
12	0	0	0	2.0 ± 0.1	-	4.6 ± 0.2
14	0	0	0	2.0 ± 0.1	-	4.6 ± 0.2

[a]Water controls.
[b]Treatment of aluminum sulfate at 150 mg L^{-1}.

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硫酸鋁對洋吉梗之瓶插壽命影響

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洋桔梗（*Eustoma grandiflorum* Shinn. cv. Hei Hou）利用硫酸鋁 0, 50, 100 及 150 mg L^{-1} 之不同濃度溶液（25°C之條件下）處理，結果顯示 150 mg L^{-1} 之處理區之瓶插壽命最久，其次是 100＞50 mg L^{-1}＞水處理之對照區。硫酸鋁 150 mg L^{-1} 與對照組之水處理相比較，顯示硫酸鋁處理區之水分蒸散顯著受到抑制，而且切花之新鮮重亦較高。主要原因是對照組之水處理區之切花在處理後第六天已明顯萎凋，而硫酸鋁 150 mg L^{-1} 之花朵壽命則可維持到處理後第十五天。實驗結果顯示，硫酸鋁之水溶液可以在 25°C 或以上之溫度條件下維持洋桔梗之切花壽命。

關鍵詞：瓶插；切花；洋桔梗；硫酸鋁。