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Full Length Research Paper

Response of some ornamental flowers of family Ranunculaceae to sucrose feeding

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The effect of different concentrations of sucrose on some ornamental flowers of family Ranunculaceae was examined. Sucrose was found to enhance vase life in cut spikes of *Aquilegia vulgaris* and *Consolida ajacis* cv. Violet blue; besides it improves blooming, fresh and dry mass of flowers. *A. vulgaris* and *C. ajacis* exhibits abscission type of flower senescence, while senescence in *Ranunculus asiaticus* cultivars is characterized by initial wilting followed by abscission at later stage. In isolated flowers of *R. asiaticus* cultivars, sucrose was found to be ineffective in delaying senescence and improving post-harvest performance. The study reveals that sucrose treatment shows varied response in different flowers of the same family and its effect appears to be related to ethylene-sensitivity of these flower systems. The paper recommends that more elaborate studies need to be conducted on other ethylene-sensitive flowers to make a generalized argument on relationship between sucrose and ethylene sensitivity.

Key words: *Aquilegia vulgaris*, *Consolida ajacis*, *Ranunculus asiaticus*, abscission, wilting, sucrose, vase life, fresh mass, dry mass, senescence, Ranunculaceae.

INTRODUCTION

As long as a flowering shoot or an inflorescence is attached to a mother plant, nutrients are continuously supplied leading to normal development. After it is detached from the plant, the supply of nutrients is cut off and the physiological processes leading to senescence are hastened (Halevy and Mayak, 1979). Improvement in the post harvest life of flowers by sugar loading has been demonstrated in a number of ethylene-sensitive flower systems (Mayak and Dilley, 1976; Monteiro et al., 2002; Pun and Ichimura, 2003; Verlinden and Vicente Garcia, 2004; Van Doorn, 2004). Very little is known about the role of sugars in ethylene-insensitive flower senescence (Eason et al., 2002). Among the different types of sugars, sucrose has been found to be the most commonly used sugar in prolonging vase life of cut flowers and the exogenous application of sucrose supplies the flowers with much needed substrates for respiration and does not only prolongs vase life, but enables cut flowers harvested at the bud stage to open, which otherwise could not occur naturally (Pun and Ichimura, 2003). Azad et al. (2008) has recently demonstrated that it is the intercellular energy depletion which serves as an early signal to trigger PCD in tulips (both cut and uncut).

Aquilegia vulgaris (white columbine) produces beautiful spikes with creamy white long–spurred flowers. The flowers possess five petals like sepals, five true petals, five pistils and numerous stamens. It is commonly cultivated as a landscape plant and as cut flower. *Consolida ajacis* (Ranunculaceae) commonly called “Rocket larkspur” possesses blue to violet flowers borne on long erect spikes (40 - 50 cm) in racemes. *Ranunculus asiaticus* cv. Red commonly known as ‘butter cup’ possesses dark red terminal flowers with a cluster of brownish anthers at centre surrounding the carpel. *R. asiaticus* hybrid possesses pinkish-yellow terminal flowers with a cluster of black or brownish anthers at centre surrounding the carpel. The present study was conducted to study the effects of different concentrations of sucrose on some ornamental flowers of family Ranunculaceae with the aim to enhance their vase life

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Table 1. Effect of different concentrations of sucrose on vase life of some ornamental flowers of family Ranunculaceae.

Plant species	Different concentrations of sucrose					
	DW (control)	0.05 M	0.1 M	0.15 M	0.2 M	LSD at $P_{0.05}$
Aquilegia vulgaris	5.0	8.5	6.0	4.0	-	0.35
C. ajacis cv. violet blue	6.8	7.2	8.5	9.3	10.6	0.44
R. asiaticus cv. Red	5.3	4.5	4.3	4.0	4.0	0.32
R. asiaticus hybrid	7.3	5.5	3.0	3.0	2.0	0.24

Each value is a mean of 10 independent replicates.

Table 2. Effect of different concentrations of sucrose on blooming in cut spikes of *A. vulgaris* and *C. ajacis* cv. Violet blue at day 6 (D6) of transfer to holding solutions.

Plant species	Different concentrations of sucrose					
	DW (control)	0.05 M	0.1 M	0.15 M	0.2 M	LSD at $P_{0.05}$
A. vulgaris	4.0 (57.2)	6.0 (85.7)	5.0 (71.4)	2.5(35.7)	-	0.72
C. ajacis	13.3(86.3)	14.3 (100)	15.0 (100)	15.0 (100)	16.6(100)	0.84

Each value is a mean of 10 independent replicates. Figures in parentheses represent percent blooms.

and to demonstrate its potential in delaying senescence in ethylene-insensitive members.

MATERIALS AND METHODS

Spikes of *C. ajacis* cv. violet blue, *A. vulgaris*, isolated flowers of *R. asiaticus* cv. red and *R. asiaticus* hybrid growing in the open at the University Botanic Garden were used for the study. In case of *C. ajacis* and *A. vulgaris,* the spikes were harvested at 1 - 2 floret open stage, while in case of *R. asiaticus* cultivars; the flowers were harvested at half-open stage. The harvested spikes and flowers were immediately brought to the laboratory, defoliated and cut to a uniform size of 35 cm in *C. ajacis*, 30 cm in *A. vulgaris* and 15 cm in *R. asiaticus* cultivars. In each case, the harvested material was transferred to Ehrlenmeyer flasks containing different concentrations (0.05 - 0.20 M) of sucrose. A separate set of spikes or flowers were transferred to flasks containing distilled water (DW), which represented respective controls. Each treatment was represented by 10 replicates (flasks) with each flask containing one spike or flower. Treatment effects were evaluated by keeping the samples in the laboratory at a temperature of 22 ± 2°C in case of *C. ajacis* and 15 ± 2°C in case of *A. vulgaris* and *R. asiaticus* cultivars, under cool white fluorescent light with a mix of diffused natural light (10 W m^{-2}) 12 h a day and RH of 60 ± 10%. The day of harvest was designated as day zero.

The average vase life of spikes was counted from the day of harvest and was assessed to be terminated when approximately 70% florets senesced on each spike. The average vase life of the *Ranunculus* flowers was counted from the day of transfer of spikes to holding solutions and was assessed to be terminated when the flowers lost their ornamental/display value (underwent colour change; wilt and loose turgidity).The experiment was maintained till the vase life in the last set of spikes/flowers was regarded to be terminated. In case of *C. ajacis* and *A. vulgaris*, number of blooms per spike was recorded at regular intervals till maximum number of buds bloomed in a particular treatment including control. Total number of buds on each spike was also counted to express the data on percentage basis. Fresh and dry mass of the flowers was also determined. Dry mass was determined by drying the material in an oven for 48 h at 70°C. The data has been analyzed statistically with SD and LSD computed at $P_{0.05}$ using MINITAB (v 15. 1.2-EQUINOX_Softddl.net) software.

RESULTS

A. vulgaris

A. vulgaris exhibited abscission type of flower senescence wherein the petaloid sepals as well as petals abscised without any significant loss of turgidity (wilting), leaving behind a group of 5 carpels surrounded by a multitude of stamens with withered anthers. The carpels registered a sharp increase in their dimensions immediately after abscission of sepals and petals and develop into five distinct follicles per flower. Feeding the spikes of *C. ajacis* with sucrose at 0.05 and 0.1 M enhanced their vase life by an increment of 1 - 4 days as compared to control (Table 1). Reduction in vase life was registered when sucrose was supplied at 0.15 M concentration. A higher fresh and dry mass was maintained in flowers from spikes fed with 0.05 M sucrose as compared to controls and also spikes supplied with higher concentrations of sucrose (Figures 1 and 2). Sucrose feeding of spikes at 0.05 and 0.1 M concentrations improved the rate of blooming as compared to controls (Table 2).

C. ajacis cv. violet blue

C. ajacis also exhibited abscission type of flower senescence wherein the petaloid sepals and petals

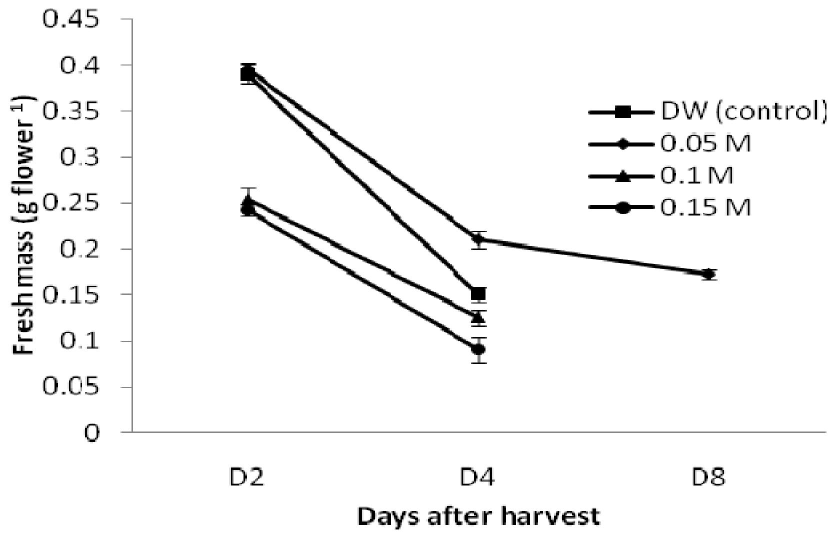

Figure 1. Effect of different concentrations of sucrose on fresh mass of flowers of *A. vulgaris* at day 2, 4 and 6 of transfer.

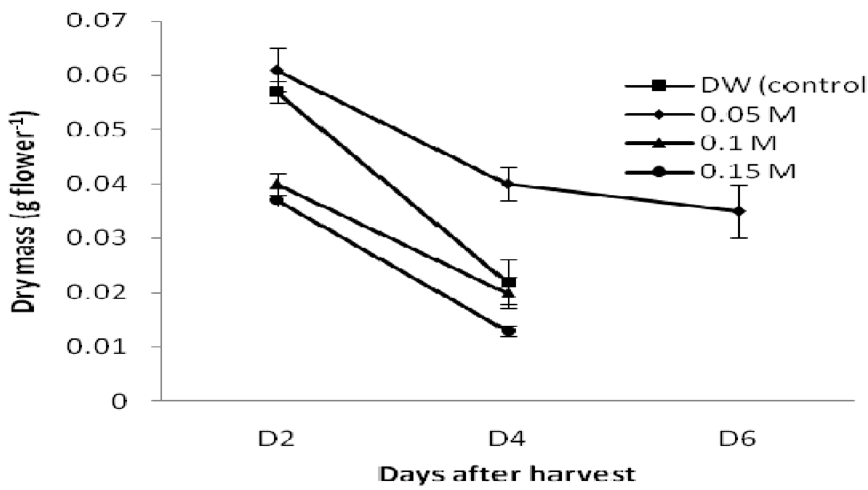

Figure 2. Effect of different concentrations of sucrose on dry mass of flowers of *A. vulgaris* at day 2, 4 and 6 of transfer.

abscise leaving behind a single carpel and a multitude of stamens with withered anthers. The single carpel registered a sharp increase in its dimensions as the other floral parts abscise, and finally developed into follicle. In *C. ajacis*, the sepals become papery and develop curvy margins immediately before they abscise. Sucrose feeding of cut spikes enhanced vase life as compared to controls (Table 1). Maximum vase life was reported in spikes transferred to 0.2 M sucrose solution, which was 3 days ahead of spikes transferred to distilled water. Fresh and dry mass of flowers increased with an increase in the concentration of sucrose. Samples from spikes supplied with 0.15 and 0.2 M sucrose resulted in higher fresh and dry mass as compared to samples from spikes supplied with lower concentrations (0.01 and 0.05 M) of sucrose (Figures 3 and 4). Sucrose feeding improved rate of blooming. 100% blooming was achieved in about 6 days in case of spikes supplied with different concentrations of sucrose as compared to controls, which achieved only 85% blooming (Table 2).

R. asiaticus cv. red

The initial symptom of petal senescence was wilting, followed by abscission at the later stage. The petals underwent a typical colour change from dark red to brick red with a loss of turgidity and lusture. Flowers underwent

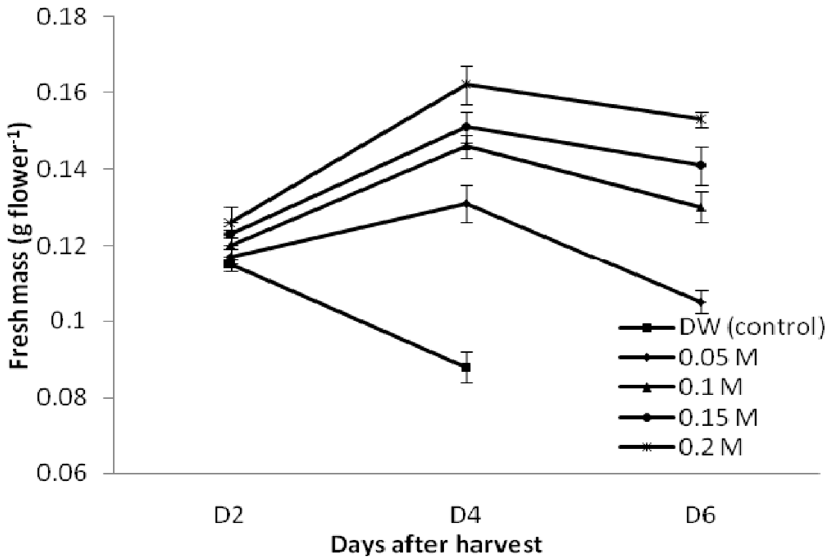

Figure 3. Effect of different concentrations of sucrose on fresh mass of flowers of *C. ajacis* at day 2, 4 and 6 of transfer.

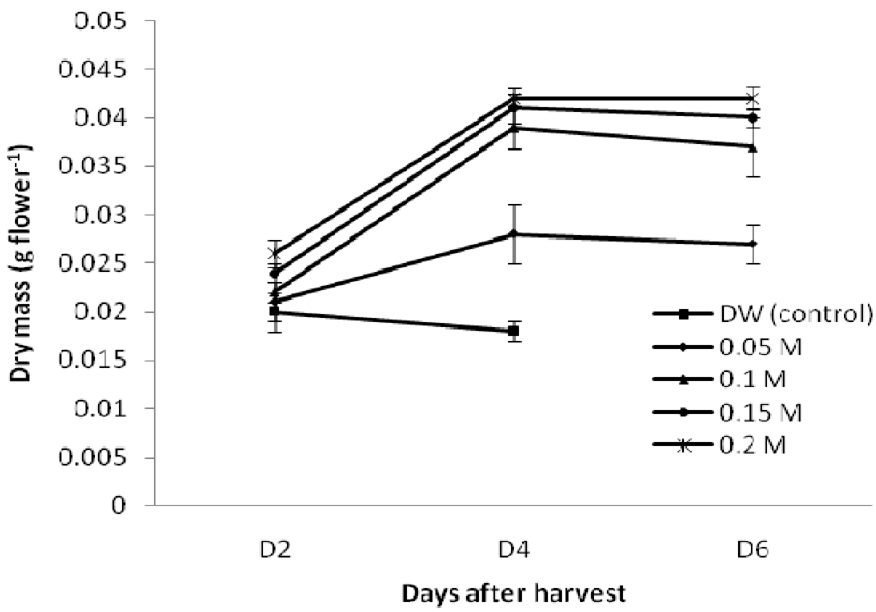

Figure 4. Effect of different concentrations of sucrose on dry mass of flowers of *C. ajacis* at day 2, 4 and 6 of transfer.

structural disorganization and finally the petals abscised. Sepals abscised much later than petals and stamens. Feeding the flowers with different concentrations of sucrose did not improve their vase life. Vase life registered a decrease with an increase in sucrose concentration. Maximum vase life was recorded in flowers transferred to distilled water (Table 1). Sucrose fed flowers at 0.05 and 0.1 M concentrations registered an increase in fresh and dry mass as compared to controls. However, a reduction in fresh and dry mass was observed in flowers supplied with 0.15 and 0.2 M sucrose (Figures 5 and 6).

R. asiaticus hybrid

The initial symptom of petal senescence was wilting, followed by abscission at the later stage. The petals lost

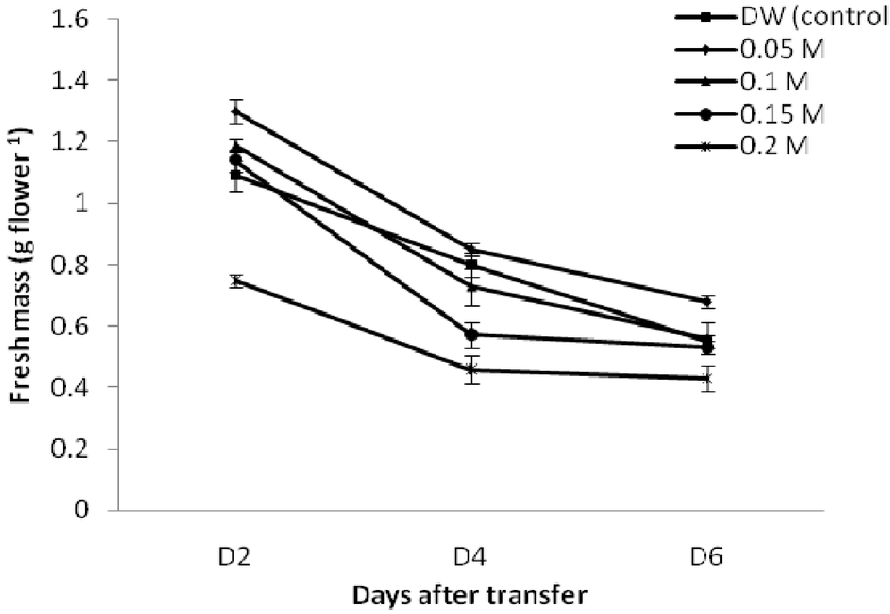

Figure 5. Effect of different concentrations of sucrose on fresh mass of flowers of *R. asiaticus* cv. red at day 2, 4 and 6 of transfer.

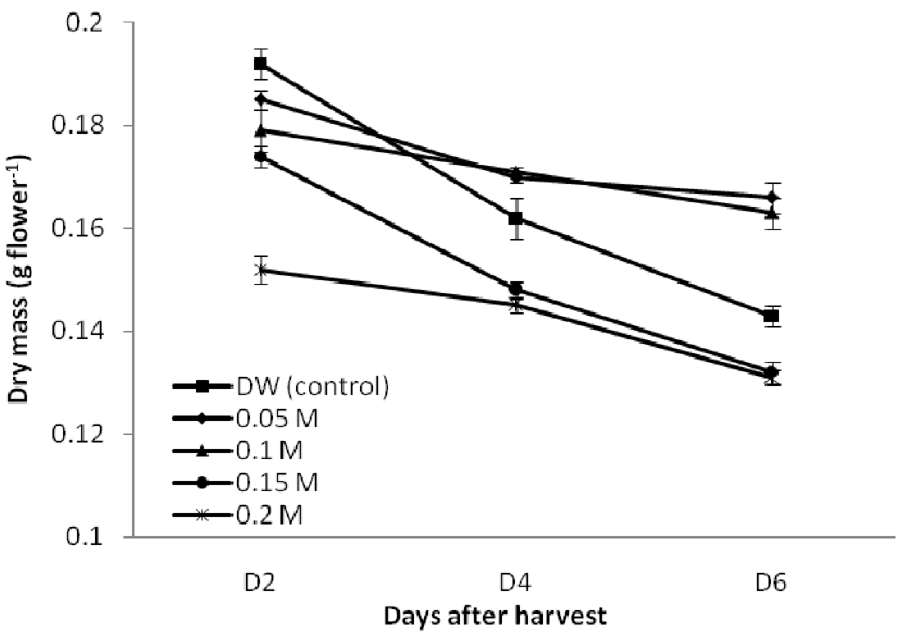

Figure 6. Effect of different concentrations of sucrose on dry mass of flowers of *R. asiaticus* cv. Red at day 2, 4 and 6 of transfer.

turgidity and lusture. Flowers underwent structural disorganization and finally the petals abscised. Sepal abscised much later than petals and stamens. Feeding the flowers with different concentrations of sucrose did not improve their vase life. Vase life registered a decrease with the increase in sucrose concentration. A drastic reduction in vase life was recorded in flowers supplied with higher concentrations of sucrose (Table 1). Maximum vase life was recorded in flowers transferred to distilled water. Sucrose fed flowers registered a general decrease in fresh and dry mass as compared to controls (Figures 7 and 8).

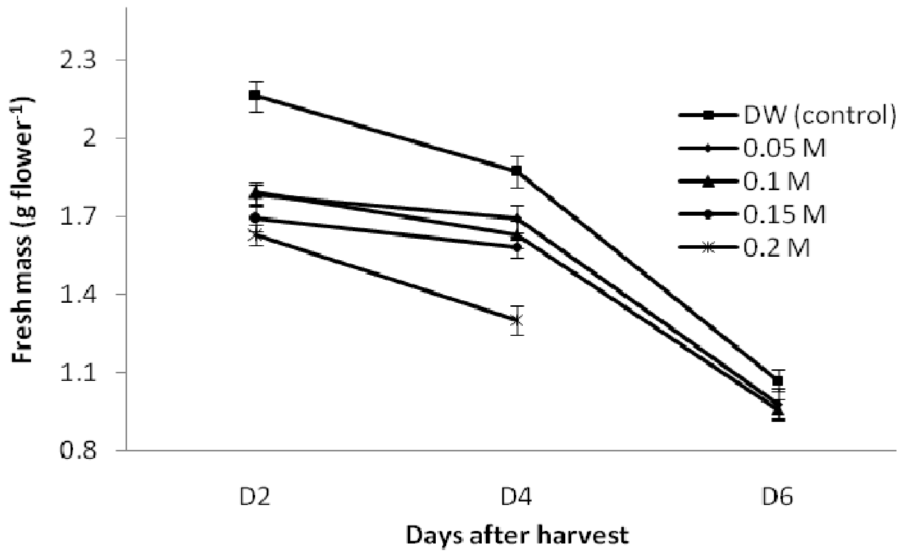

Figure 7. Effect of different concentrations of sucrose on fresh mass of flowers of *R. asiaticus* hybrid at day 2, 4 and 6 of transfer.

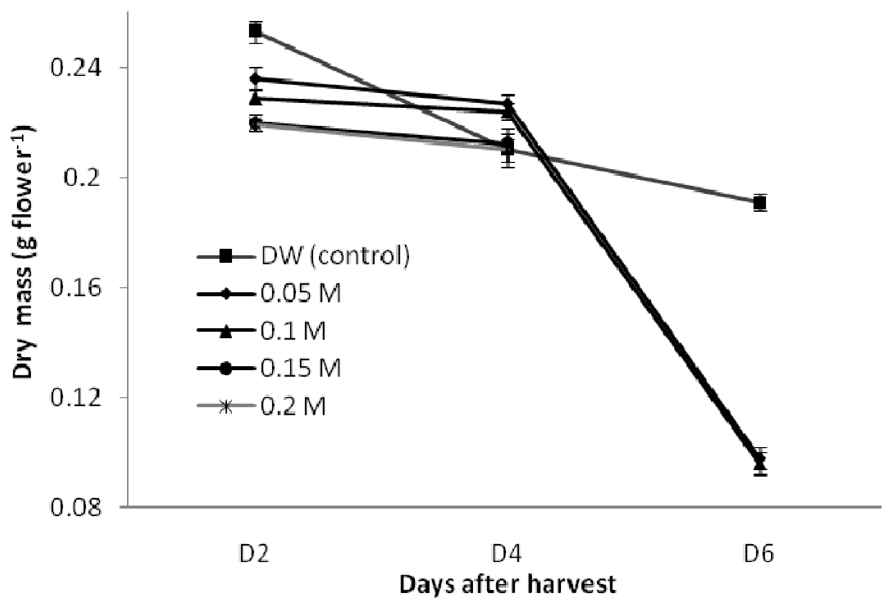

Figure 8. Effect of different concentrations of sucrose on dry mass of flowers of *R. asiaticus* hybrid at day 2, 4 and 6 of transfer.

DISCUSSION

The results of our experiments suggest that sucrose at 0.05 and 0.2 M significantly enhanced vase life of cut spikes of *A. vulgaris* and *C. ajacis*, respectively, while it was found ineffective in enhancing vase life of cut *R. asiaticus* cultivars. Ethylene sensitivity in *A. vulgaris* is not known yet, but *C. ajacis* has been found to be ethylene-sensitive (Finger, 2001; Dole et al., 2005), while *R. asiaticus* cultivars (Kenza et al., 2000; Dole et al., 2005) as ethylene-insensitive. The beneficial effect of sugars on flower senescence has been attributed to the supply of substrates for respiration, structural materials and osmoticum (Halevy and Mayak, 1979), and has been attributed to the suppression of ethylene biosynthesis or sensitivity to ethylene (Ichimura and Hisamatsu, 1999; Ichimura and Suto, 1999; Ichimura et al., 2000; Liao et al., 2000; Pun and Ichimura, 2003). It suggests the existence of some relationships between sucrose and ethylene production during flower senescence. Exogenous sugars have been found to delay visible senescence in flowers with ethylene-sensitive petal senescence, but having only a small or no effect in flowers with ethylene-insensitive petal senescence (van Doorn and Stead, 1994; van Doorn, 2004). Sugars have been found to delay the increase in mRNA abundance of a number of senescence-associated genes (Eason et al., 2002; Hoeberichts et al., 2007). It may therefore be, suggested that lack of ethylene-sensitivity of *R. asiaticus* cultivars may be one of the factors contributing to the ineffectivity of sucrose in delaying their senescence and improving postharvest life. In case of *A. vulgaris* and *C. ajacis* spikes, sucrose feeding maintained higher fresh and dry mass of flowers as compared to controls. It is suggested that sucrose induces the closure of stomata, eventually reducing the loss of water, thereby, reducing transpiration and maintaining the fresh mass (Marousky, 1969; Chen et al., 2001). Maintenance of dry mass of flowers could be also due to lower respiratory losses as sucrose has been found to suppress respiration in certain plant tissues by delaying climacteric rise in ethylene biosynthesis (Dilley and Carpenter, 1975; Ichimura and Suto, 1999; Zhang and Leung, 2001; Ichimura et al., 2000). Spikes of *A. vulgaris* and *C. ajacis* fed with sucrose showed an improvement in rate of blooming by promoting opening of immature buds.

The study reveals that sugar status is one of the factors responsible for shorter vase life of *A. vulgaris* and *C. ajacis* spikes, while in *R. asiaticus* cultivars, other factors might be involved. Although the study is of preliminary nature, it is important in the context that little information is available regarding the use of sucrose in ethylene-insensitive flower systems. The study also suggests that more elaborate studies need to be conducted on other ethylene-sensitive flowers to make a generalized argument on relationship between sucrose and ethylene sensitivity.

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