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Effect of Gibberellic Acid Pulsing and Sucrose Continuous Treatment on Some Qualitative Characteristics of Cut Rose Flower cv. Velvet

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Abstract

The aim of this study was the better assessment of the relationship of pulsing treatment of gibberellic acid as an anti-senescence agent and holding in sucrose as a carbohydrate supply resource on improving some qualitative and physiological attributes of cut rose flower cv. Velvet. Hence, an experiment involving the pulsing treatment with gibberllic acid (GA_3) at 0, 20, 40 and 60 mg L^{-1}, for 24 hours, and holding them in sucrose at 0, 2 and 3% with 250 mg L^{-1} of 8- HQS as an antimicrobial agent for all holding treatments was conducted. The study was performed as a factorial experiment based on a randomized completely design (RCD) with three replication for each combination treatment. Applying GA_3 pulse treatment alone at all concentrations increased significantly vase life and its effect enhanced with sucrose holding at 2 and 3% compared with control. The effect of GA_3 pulsing in increasing of stem relative fresh weight (RFW) and solution uptake (SU) was hastened by sucrose holding treatment at 2 and 3%. Highest amount of flower opening and petal water content during vase life period was observed in 60 mg L^{-1} of GA_3 pulsing and sucrose 3% holding treatment which had been longer flower diameters and greater petals. Gibberellic acid pulsing alone and along with sucrose holding treatment at all concentrations caused to prevention of leaf chlorophyll degradation compared with control. In conclusion, GA_3 pulsing at 40 mg L^{-1} along with sucrose 2% holding treatment had a significant effect on improving vase life and other qualitative attributes of cut rose flower cv. Velvet.

Keywords: Carbohydrate, Cut rose, Plant growth regulators, Vase life, Water uptake.

INTRODUCTION

Senescence of cut flowers is under hormonal control and related to the changes in the carbohydrate status of the petals (Halevy and Mayak, 1981). The GA_3 is considered to be a senescence- delaying plant growth regulator (Arteca, 1996). Pulsing alstromeria flowers for 24 h with a 0.01 mmol GA_3 solution increased longevity of cut flowers (Jordi *et al*., 1995). Sabehat and Zieslin (1995) also noted that GA_3 treatment increased the vase life of roses. Hunter *et al*. (2004) found that treatment with GA_3 repressed accumulation of the seven senescence associated transcripts in daffodil. It has recently been shown that treatment of flower with cytokinins and gibberellins can delay the senescence of cut flowers. Results of Ganelevin and Zieslin (2002) showed that it is possible that sepals are as a source of gibberellic acid during flower bud development. Removing sepals, reduces fresh and dry weight, with the buds and peduncle length. Gibberellic acid changes critical rate of ethylene that increase vase life (Saks and Staden, 1993). Singh *et al.* (2008) demonstrated that the vase solution treatment combinations of GA_3 and benzyladenine with sucrose significantly increased the vase life of cut spikes of gladiolus as compared to the sucrose alone treatment or the control. However, the results obtained have been variable. Boose and van Staden (1989) demonstrated that the efficiency of these compounds depends on the mode of application as well as the type and concentration of a cytokinin used. The aim of the present work was to determine the effect of benzyladenine and gibberellic acid at different concentrations, used in a pulse treatment solution, on the longevity of rose 'Red One'.

Cut flower longevity has been associated with the concentration of carbohydrates in the cut flowers (Halevy and Mayak, 1981). The final stages of flower development are characterized by a decline in the content of carbohydrates and dry weight of petals. The gradual decline during respiration in aging flowers may be caused by short supply of readily respirable substrates, mainly sugars. It was suggested that the content of these substrates may indicate the potential life of the flower at a specific temperature (Nichols, 1973). Translocation within the flower from the petals to the ovary was also demonstrated in senescing flowers (Nichols, 1976). Sucrose mostly is common as a pulsing treatment for cut flowers. By treatment of cut flowers with external carbohydrates, maintains dry matter content and level respiration, in result increases longevity cut flowers (Kuiper *et al.,* 1995). Also, sugars improves water balance in the plant and are effective in the regulation of stomata and through this reduces water evaporation (Sarka, 2004). Different concentrations of sucrose had been investigated by Butt (2005) on two cultivars of *Rosa hybrida* and results showed that sucrose at 25 g L^{-1} extended the vase life by 8.2 days in var. Whisk Mac and 7.5 days in var. Triska as compared to 5.3 days in control. The aim of this study was the better assessment of the relationship of pulsing treatment of gibberellic acid as an anti-senescence agent and holding in sucrose as a carbohydrate supply resource on improving some qualitative and physiological attributes of cut rose flower cv. Velvet.

MATERIALS AND METHODS

Plant material, experimental design and treatments

Cut rose flowers cv. Velvet (*Rosa hybrida*) was prepared from Mahan commercial greenhouse in Tabriz Iran. This experiment was performed in October 2013 in the postharvest biology Laboratory of a Department of Horticultural Sciences of University of Tabriz based as a factorial experiment based on randomized completely design (RCD) consisting of 12 treatments and 3 replications with 4 cut stems in each treatment combination. As soon as the flowers arrived to the lab, their thorn and lower leaves of the cut stem was removed gently. Prior to treatment, rose stems were trimmed to a length of 50 cm and then they pulse treated with gibberellic acid (GA_3) solution at four levels (0, 20, 40 and 60 mg/l) for 24 hours in glass containers and then held in vases included sucrose solution at 3 levels (0, 2 and 3 %) with 250 mg/l of the 8-hydroxyquinoline sulfate (8-HQS). Cut flowers were kept at room temperature (23 ±2°C), relative humidity 60±5% and the light intensity of 12 µmol/m^{-2}.$s^{-1}$of cool white fluorescent lamps with 12 hours of light until the end of vase life.

Table 1. Effect of Gibberellic acid (GA_3) pulsing and sucrose holding treatment on vase life of cut rose cv. Velvet.

Treatments Sucrose	Vase life (days)		
	0%	2%	3%
Control	8.4 d	10.5 c	12 c
GA_3 20 mg L^{-1}	13.66 b	14.83 ab	14 b
40	14.8 ab	16.6 a	16.9 a
60	14.5 ab	15.8 a	15.7 a
LSD $_{0.05}$= 1.6 (n= 3)			

Each value represents a mean of three replicates. Means followed by the same letters were not significantly different at 5% level of significance.

Measurements

Vase life

During the vase-life period, the visual quality of cut flowering stems was inspected daily. In our study, vase-life was defined as the period from the time of cutting to the time when 50% of floret petals wilted or abscised or floret necks bent as described by Liao *et al.* (2000).

Solution uptake, relative fresh weight and flower diameter

The cut flowers fresh weight and the solution uptake rate were measured daily. The weight of vases with and without cut flowers was recorded daily. Mean daily solution uptake (g $stem^{-1}$ day^{-1}) was computed using the formula (St_{-1}−St), where St is the weight of vase solution (g) at t=day 1, 2, 3,…, and n. Relative fresh weight (RFW) of stems was computed using the formula RFW (%)=(Wt/W0)×100, where, Wt is the weight of stem (g) at t=day 0, 1, 2…, and n, and W0 is the weight of the same stem (g) at t=day 0 (He *et al.*, 2006). Flower diameter was measured as an index for petals expanding rate. The outer diameter of opened flowers was measured by a Vernier Caliper (mm).

Leaf chlorophyll index, dry weight and petal water content

Chlorophyll Index was measured by a SPAD-502 (Minolta Co., Japan). All readings were carried out between the tip and the base of fully expanded leaves in each sample. Fresh weight of petals was recorded and petal dry weight was recorded after drying at 105 °C for 48 h in an electrical oven until constant weight was obtained. Petal water content was determined as the percentage of total petal weight [(FW – DW)/FW×100] by weighing samples of all petals from a single flower.

Statistical analysis

The recorded data were subjected to analysis of variance (one-way ANOVA) using the general linear model program of SPSS software (SPSS Ver. 16). Means were compared by the least significant difference (LSD) test at the 0.05 probability level.

RESULTS

Vase life

Sucrose holding of cut stems alone had a significant effect ($p<0.05$) on increasing vase life compared with control. Gibberellic acid (GA_3) pulsing at all concentrations had significantly ($p<0.05$) longer vase life than the control. Pulsing by gibberellic acid alone at all concentrations gave a vase life improvement compared with control and sucrose alone treatments (2% and 3%). However, the combination treatments of gibberellic acid and sucrose holding showed that the concentration 40 mg/l of gibberellic acid pulsing alone and its combination with sucrose (2% and 3%) had longer vase life values compared with other levels (Table 1).

Table 2. Effect of Gibberellic acid (GA_3) pulsing and sucrose continuous treatment on relative fresh weight (RFW), solution uptake (SU) of cut rose cv. Velvet.

Treatments Sucrose	RFW (%)			SU (g stem^{-1} day^{-1})		
	0%	2%	3%	0%	2%	3%
Control	96.3 ^{c}	105.85 ^{ab}	107.65 ^{a}	1.25 ^{c}	2.82 b	3.41 ^{a}
GA_3 20 mg L^{-1}	96.9 ^{c}	104.95 ^{b}	105.7 ^{ab}	2.43 ^{b}	3.05 ^{a}	3.87 ^{a}
40	95.2 ^{c}	105.6 ^{ab}	107.05 ^{a}	2.54 ^{b}	3.27 ^{a}	3.83 ^{a}
60	95.1 ^{c}	107.7 ^{a}	109.33 ^{a}	2.76 ^{b}	3.55 ^{a}	3.88 ^{a}
LSD $_{0.05}$ (n= 3)		2.17			0.95	

Each value represents a mean of three replicates. Means with the same letter were not significantly different at 5% level of significance (P < 0.05).

Table 3. Effect of gibberellic acid (GA_3) pulsing and sucrose holding on leaf chlorophyll index (LCI) and flower diameter (FD) of cut rose cv. Velvet.

Treatments Sucrose	LCI			FD (mm)		
	0%	2%	3%	0%	2%	3%
Control	48.3 ^{c}	50.8 ^{c}	52. 5 ^{c}	38.2 ^{g}	40.3 ^{f}	43.6 ^{ed}
GA_3 20 mg L^{-1}	53.2 ^{b}	54.95 ^{b}	56.6 ^{ab}	40.2 ^{f}	42.5 ^{e}	44.3 ^{d}
40	58.2 ^{ab}	58.6 ^{ab}	59.8 ^{a}	42.2 ^{e}	48.4 ^{c}	53.5 ^{b}
60	62.3 ^{a}	62.7 ^{a}	63.3 ^{a}	45.5 ^{d}	52.6 ^{b}	55.3 ^{a}
LSD $_{0.05}$ (n= 3)		3.85			1.78	

Each value represents a mean of three replicates. Means with the same letter were not significantly different at 5% level of significance (P<0.05).

Solution uptake, relative fresh weight and flower diameter

Cut stems pulsed with GA_3 at all concentrations (20, 40 and 60 mg L^{-1}) and holding at 2 and 3 % of sucrose solution showed markedly relative fresh weight amounts compared with control. However holding them at sucrose solution (2 and 3%) alone had a significant effect in increasing RFW values in comparison to control (Table 2).

Results showed that the increasing effect of RFW values of cut stems dependent to the sucrose concentration of the vase solution alone. Solution uptake of cut stems, improved significantly by gibberellic acid pulsing and sucrose alone treatments. The maximum amount of solution uptake (3.88 g stem^{-1} day^{-1}) was observed at all concentrations of GA_3 pulsing with sucrose 3% holding treatment (Table 2). Flower diameter in all treatments, significantly increased by GA_3 pulsing and sucrose holding as its maximum flower bud opening (55 mm) was observed at GA_3 60 mg L^{-1} pulsing with sucrose 3% holding treatment and its minimum rate was belong to control (38.2 mm) (Table 3).

Leaf chlorophyll index, flower petal dry weight and water content

Our results showed that leaf chlorophyll index values of cut rose cv. Velvet increased significantly by GA_3 pulsing alone with maximum value (62.3) in concentration of 60 mg L^{-1}. Sucrose holding treatment of 3% with GA_3 pulsing treatment (40 and 60 mg L^{-1}) significantly had higher levels of leaf chlorophyll index compared with 20 mg L^{-1} and control (Table 3). There was no significant difference among flower petal dry weight values for both treatments. Higher amounts of flower petal water content was observed in all concentrations of GA_3 pulsing with all concentrations of sucrose holding treatment compared with control. The maximum rate of flower petal content (83.3%) was observed in 60 mg L^{-1} with 3% of sucrose vase solution (Table 4).

Table 4. Effect of gibberellic acid (GA_3) pulsing and sucrose holding on flower petal dry weight (PDW) and flower petal water content (PWC) of cut rose cv. Velvet.

Treatments Sucrose	PDW (g)			PWC (%)		
	0%	2%	3%	0%	2%	3%
Control	0.17	0.18	0.20	65.2 ^{e}	68.3 ^{de}	73.6 ^{c}
GA_3 20 mg L^{-1}	0.17	0.2	0.27	68.2 ^{de}	77.5 ^{b}	79.3 ^{b}
40	0.18	0.25	0.27	70.2 ^{d}	75.4 ^{c}	78.5 ^{b}
60	0.18	0.28	0.28	$^{71.5}$ cd	$^{78.6}$ b	83.3 ^{a}
$LSD_{0.05}$ (n= 3)		ns			2.48	

Each value represents a mean of three replicates. Means with the same letter were not significantly different at 5% level of significance (P<0.05) , ns: LSD-test was not significant (P<0.05).

DISCUSSION

One of the main problems in the postharvest of cut rose flowers is stem collapse, known as bent neck (Dole and Wilkins, 1999). Bent neck is caused by insufficient flower stem hardening, maturation of the stem tissue below the harvested flower or low levels of dry matters, water content of cut flowers (Nowak and Rudnicki, 1990). It has been reported that GA_3 delays wilting and senescence as associated proteolysis (Eason, 2002). In an experiment on 5 rose cultivars which was performed by Goszczynska *et al*. (1990), vase life of cv. Mercedes increased significantly as in detached petals by gibberellic acid treatment. Our results revealed that using GA_3 pulsing at 40 and 60 mg L^{-1} significantly increased vase life of cut stems than the control and delaying bent neck of cut rose cv. Velvet (Table 1), by improving flower petal water content and solution uptake (Tables 2 and 4). Similar results have been reported in gerbera cut flowers with GA_3 treatment (Emongor, 2004; Danaee *et al.*, 2011).

The GA_3 along with sucrose has been suggested to induce water uptake in cut flowers of gerbera (Emongor, 2004). In fact gibberellic acid caused negative osmotic potential cell and increase water uptake by hydrolysis of starch and sucrose (Goszczynska and *et al.*, 1990). Singh and *et al.* (2008) reported that 50-500 mg/l gibberellic acid spray over cut roses increases water uptake. Water shortages caused when the amount of transpiration is more than water uptake (Nowak and Rudnicki, 1990). Also gibberellins continue to modulate growth of flowers after harvest as evidenced by increased fresh weight of cut roses upon application of GA_3 (Sabehat and Zieslin, 1995). Our results showed that with increasing sucrose concentration the amount of relative fresh weight of cut stems and solution uptake enhanced (Table 2). In a study by Elgimabi and Ahmad (2009) observed that the 3% sucrose treatment had more longevity than sucrose 2% and 1%, which similar to our results which obtained in this study. Improvement of the postharvest life of flowers by sugars has been demonstrated for many years and most pulsing and holding solutions applied to cut flowers include sucrose (Halevy and Mayak, 1981). It is widely thought that sugar treatment prolongs the vase life by increasing the levels of respiratory substrate (van Doorn, 2001). Apparently, this sugar provides energy for fundamental cellular processes, such as maintenance of the structure and function of mitochondria and other organelles (Capdeville *et al*., 2003). Increased sucrose concentration enhanced petal growth in detached flowers of *Eustoma grandiflorum* (Kawabata *et al.,* 1995). It is known that sucrose improves water balance in cut flowers (Halevy and Mayak, 1974). After the supplied sugar reached the flower head, an improvement in water balance was observed (Borochov *et al.*, 1976).

Our results showed that with increasing concentration of gibberellic acid pulsing treatment flower opening process is increased too as it caused to higher values of flower diameter than control (Table 3). Skutnik *et al.* (2001) showed that a pulse treatment with GA_3 greatly improved the postharvest performance of *Zantedeschia aethiopica* leaves and dramatically reduced the normal increase in pH and conductivity of the cell sap. The role of GA in petal growth has been demon-

strated in many plants and seems to be a general phenomenon (Pharis and King, 1985). Gibberellin treatments increased the size of flowers. The possibility is discussed that GA, which is exogenously supplied, enhances flower dimensions and keep flower pigmentation by drawing photosynthates to the flower as a consequence of intensification of the sink (Zieslin *et al.*, 1974).

GA significantly protects the chlorophyll in plants and prevents leaf yellowing during postharvest period, in some plants such as lily, Alstroemeria which can be stored for a long time and caused to increase the vase life (Lukaszewska, 1995). In Easter lily leaves, the senescence delaying effect of GA_3 was associated with depression of the respiration rate (Han, 1995). Saks and van Staden (1993) reported that GA_3 treatment reduced levels of ACC and ethylene production. In our research higher values of leaf chlorophyll index was observed in GA_3 pulsing treatment of 40 and 60 mg L^{-1} at the end of vase life of cut rose cv. Velvet than control (Table 3). This hormone prevents the degradation of chlorophyll in plants (Ichimura and Goto, 2000), this may be due to decrease in pH cell sap and to prevent of degradation chlorophyll that protects chlorophyll (Skutink *et al.,* 2001). Gibberellic acid decrease chlorophyll degradation and loss during the senescence process, because of its role strengthening in the membrane of chloroplasts.

CONCLUSION

In conclusion, GA_3 pulsing at 40 mg L^{-1} along with sucrose 2% holding treatment had a significant effect on increasing vase life of cut rose cv. Velvet and improved their flower quality by increasing solution uptake, fresh weight, flower diameter, and leaf chlorophyll index therefore enhancing flower quality and delaying senescence.

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