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EFFECT OF CITRIC ACID ON VASE LIFE, SOLUTION UPTAKE AND CHLOROPHYLL CONTENT OF CUT LISIANTHUS (*Eustoma grandiflorum* L.) FLOWERS

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ABSTRACT

Lisianthus (*Eustoma grandiflorum* L.) is an ornamental plant which contains one of the world's top cut flowers. Vase life of cut Lisianthus flower is relatively short. Citric acid is an organic compound and a natural acid. Different concentrations of citric acid were used as preservative solutions aiming to extend the vase life of cut Lisianthus flowers. These flowers; at optimum developmental stage was treated with a vase solution containing citric acid at concentrations of 0, 50, 100 and 200 mg l^{-1}. Longevity of cut Lisianthus flowers was determined on the basis of wilting and chlorophyll retention. Cut Lisianthus was kept at room temperature (20±2°C) under normal day light and natural ventilation. The greatest longevity of vase life (15.37 days) was related to 200 mg l^{-1}citric acid. This treatment increased cut vase life more than six days longer that the control treatment. The maximum solution uptake (4.82 ml g^{-1} F.W.) was calculated in 200 mg l^{-1}citric acid. The highest total chlorophyll content (8.40 mg g^{-1} F.W.) was obtained in 100 mg l^{-1} citric acid. The present study concludes that it would be possible to use solutions containing citric acid to maximize extending the vase life of cut Lisianthus flowers.

Keywords: vase solutions, citric acid, chlorophyll content, flower longevity, ornamental plants, water absorption.

INTROUCTION

Lisianthus (*Eustoma grandiflorum)* is an ornamental plant with beautiful flowers. This species quickly ranked in the top ten cut flowers worldwide due to its rose-like flowers and being available in various colors (Kunitake *et al*., 1995). This plant grows to 50-75 cm in height with 20-40 flowers. Lisianthus has the qualities of an "ideal cut flower" and should continue to increase in popularity throughout the next century. The cut inflorescences typically have a vase life of 3 to 6 weeks (Dennis *et al*., 1989).

Vase life of cut Lisianthus flowers are usually short. Vase life of cut flowers is related to physio-chemical processes and reduces through ethylene production and bacterial contamination in vase solution (Nowak and Rudnicki, 1990; van Doorn *et al*., 1997; Alaey *et al*., 2011). Short vase life is highly influenced by water loss and wilting during transpiration (van Doorn *et al*., 1997). Some treatments have been applied to increase the vase life of cutflowers by regulating water balance, distribution of assimilates, delaying senescence and blocking microbial agents (Alaey *et al*., 2011). Water balance is a main factor determining quality and longevity of cut flowers (da Silva, 2003). The major form of vascular occlusion is the blockage of xylem vessels by air emboli and microorganisms (van Doorn, 1997). Microorganisms, especially bacteria and fungi which grow in preservative solutions have a main adverse effect on the longevity of cut flowers. These microorganisms and their products plug the stem ends and restrict the water absorption, which reduce the longevity of cut flowers (van Doorn *et al*., 1997; Alaey *et al*., 2011). Microbes can also produce ethylene and secrete toxic compounds, also pectinase and accelerated senescence. Ethylene is major plant growth regulator related to senescence and its external application causes accelerated senescence (Reid and Wu, 1992). Several agents have been used in cut flower vase solution to extend vase life by improving water uptake (Lü *et al*., 2010).

Citric acid like other organic acids can influence on the vase life of cut flowers. Organic acids are source of both carbon and energy for cells and are used in the respiratory cycle and some other biochemical pathway (da Silva, 2003; Darandeh and Hadavi, 2012). Citric acid reduces bacterial population in vase solution and increases the water conductance in xylem of cut flowers (van Doorn, 1997). Citric acid is one of the mobile forms of iron in plants, thus it plays an important role in iron transport (Hell and Stephan, 2003; Darandeh and Hadavi, 2012). The positive effect of citric acid on postharvest longevity of some cut flowers like *Lilium* and tuberose was reported (Eidyan, 2010; Darandeh and Hadavi, 2012). The purpose of this study was to evaluate of different concentrations of citric acid on vase life, solution uptake and chlorophyll content of cut Lisianthus (*Eustoma grandiflorum* L.) flowers.

MATERIALS AND METHODS

Cut Lisianthus (*Eustoma grandiflorum* L.) flowers were obtained from aneconomic producer in Tehran, Iran at their optimum developmental stage. They were immediately stood in buckets and transported to the postharvest laboratory. Buckets containing the flower stems were covered with a plastic film shroud to minimize moisture loss during transportation. At the laboratory, stems were re-cut under deionized water. The flowers were selected for uniformity of size, color and freedom from any defects.

The experimental design was a randomized completely blocks design (RCBD) with four treatments

containing 0, 50, 100 and 200 mg $l^{-1}$of citric acid and four replications. In each experiment, five cut Lisianthus flowers were placed into 1000 mL vase filled with 250 mL of preservative solutions including the aforementioned concentrations of citric acid and 500 ml of 3% sucrose. Distilled water was used as a control. The mouths of the pots were covered with a sheet of low density polyethylene film to minimize evaporation and to prevent contamination. The flowers were kept in a vase life room under the following conditions: 20 ± 2°C, relative humidity of 60-70%, 12 µmol $m^{-2}s^{-1}$ light intensity (cool white florescent tubes) and a daily light period of 12 h.

Criterion for the end of vase life was the time that flowers were showing symptoms of petals wilting or curling. Vase life was the period from the time of putting the cut flowers into the second preservative solution until the end of vase life.

Solution uptake was calculated as following formula:

Solution uptake = 500 - (volume of rest solution at the end day + mean of evaporation of 4 vase at that time

Chlorophyll contents of leaves were measured using spectrophotometry after five days. Chlorophyll was extracted by acetone 80% and measured by following formula:

Chlorophyll a = 9.93 (A_{660}) - 0.777 (A_{643})

Chlorophyll b = 17.6 (A_{643}) – 2.81 (A_{660})

Total chlorophyll = 7.12 (A_{660}) – 16.8 (A_{643})

Data were subject to analysis of variance (ANOVA) and means were compared by the least significant difference (LSD) test at $p \leq 0.05$ using SPSS statistical software.

RESULTS AND DISCUSSIONS

Citric acid increased vase life of cut Lisianthus (*Eustoma grandiflorum* L.) flowers significantly ($p \leq 0.05$) (Table-1). The mean comparison among treatments showed that the vase life was maximum (15.37 days) in cut flowers treated with 200 mg l^{-1} citric acid (Table-2). This treatment increased the vase life of cut flowers about 2 times more than that of control cut flowers (8.50 days). Positive effect of citric acid on post-harvest of several cut flowers has been shown (Eidyan, 2010; Darandeh and Hadavi, 2012). Study of Darandeh and Hadavi (2012) on the effect of pre-harvest foliar application of citric acid on vase life of *Lilium* revealed that 0.15% citric acid alone increased vase life from 11.8 in control treatment to 14 days. The use of other organic compounds such as ascorbic acid and malic acid for increasing the vase life of cut flowers has been reported by some researchers (Kazemi *et al*., 2010; Darandeh and Hadavi, 2012; Abdulrahman *et al*., 2012; Jamshidi *et al*., 2012; Banaee *et al*., 2013; Abri *et al*., 2013). Bouna

Table-1. Analysis of variance (ANOVA) of the effect of different concentrations of citric acid on various traits in cut Lisianthus (*Eustoma grandiflorum* L.) flowers.

Source of variations	df	Vase life	Solution uptake	Chlorophyll a	Chlorophyll b	Total Chlorophyll
Treatment	3	16.570*	1.730**	3.390**	0.896**	7.290**
Error	9	6.920	0.236	0.026	0.021	0.015
CV (%)		20.13	12.84	3.27	6.10	1.67

**: significance level at 1%, *: significance level at 5%

Table-2. Mean comparison of the effect of different concentrations of citric acid on various traits in cut Lisianthus (*Eustoma grandiflorum* L.) flowers*.

Citric acid (mg l^{-1})	Vase life (day)	Solution uptake (ml g^{-1} F.W.)	Chlorophyll a (mg g^{-1} F.W.)	Chlorophyll b (mg g^{-1} F.W.)	Total Chlorophyll (mg g^{-1} F.W.)
0	8.50^{b}	2.55^{d}	4.87^{c}	2.78^{a}	7.66^{b}
50	14.00^{a}	3.55^{c}	3.17^{d}	1.77^{c}	4.95^{c}
100	12.00^{ab}	4.37^{ab}	5.67^{a}	2.73^{a}	8.40^{a}
200	15.37^{a}	4.82^{a}	5.09^{b}	2.44^{b}	7.54^{b}

*Values in each row that are followed by the same letter are not significantly different by LSD test.

Solution uptake was affected by citric acid ($p \leq 0.01$) (Table-1). Cut flowers in the solution containing 200 mg l^{-1} citric acid showed the maximum solution uptake rate (4.82 ml g^{-1} F.W.) (Table-2). All concentrations of citric acid improved solution uptake than the control (2.55 ml g^{-1} F.W.) (Table-2). Preferential solution uptake of cut flowers incubated in citric acid suggesting a possible decrease in xylem blockage due to reduced microbial growth. Positive effect of citric acid may be attributed to its antimicrobial activity that reduce bacterial population and resulted in increase the vessels conductivity and water uptake. Low water uptake by cut

flowers is often due to occlusions located mainly in the basal stem end (He *et al*., 2006) and microorganisms and their decay products are a common cause of stem end blockage (van Doorn, 1997; Williamson *et al*., 2002). In many cut flowers, suppression of microbial growth in the vase solution results in delayed wilting (van Doorn, 1997). Based on the present results, the chlorophyll content was affected by citric acid ($p \leq 0.01$) (Table-1). The least total chlorophyll content (4.95 mg g^{-1} F.W.) was observed in cut Lisianthus flowers treated with 50 mg l^{-1}citric acid. The highest total chlorophyll content (8.40 mg g^{-1} F.W.) was observed in cut flowers treated with 100mg l^{-1} citric acid (Table-2). Darandeh and Hadavi (2012) studies revealed that citric acid alone did not alter the content of chlorophyll significantly than the control.

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