South Western Journal of Horticulture, Biology and Environment
P-Issn: 2067- 9874, E-Issn: 2068-7958

Vol.3 , No.1, 2012
pp.41-53

POSTHARVEST LIFE OF ALSTROEMERIA CUT FLOWERS IS EXTENDED BY THIDIAZURON AND BENZYLADENINE

Abdollah HATAMZADEH,
Shirin REZVANYPOUR* and Moazzam HASSANPOUR ASIL

Department of Horticultural Sciences, Faculty of Agricultural Sciences,
University of Guilan, Rasht, Iran.
*Corresponding author: shirin.rezvany@gmail.com

Abstract. *Early leaf yellowing in Alstroemeria cut flowers before petal abscission is an important limiting vase life factor. Leaf senescence can be reduced by application of cytokinins, but this effectiveness on cut flowers can be different depending on cultivar, stage of flower development and type of cytokinin. In this study, the effect of adding benzyladenine (BA) and thidiazuron (TDZ), a substituted phenylurea compound with high cytokinin-like activity, to solutions containing sucrose and hydroxyquinoline sulfate for increasing flower and leaf longevity of Alstroemeria cut flowers (Alstroemeria hybrid cv. Setpoint) was investigated. Results showed that pulse treatment of Alstroemeria cut flowers with 30 g L^{-1} sucrose + 10 µM thidiazuron + 200 mg L^{-1} hydroxyquinoline sulfate significantly delayed petal abscission (3.3 days) and leaf yellowing (25.7 days) compared to untreated control flowers. This treatment increased chlorophyll content, fresh weight, water uptake and total soluble solids of petals. Application of BA had no significant ($p<0.05$) effect on delaying time to petal abscission and it was less effective than TDZ on delaying chlorophyll degradation.*

Key words: *Alstroemeria, Benzyladenine, Flower longevity, Thidiazuron.*

INTRODUCTION

The postharvest life of *Alstroemeria* floral organs is typically long and is terminated by petal abscission. However, in many cultivars, yellowing of the leaves on cut stems occurs within a few days, and proceeds very rapidly (Ferrante et al. 2002, 2003, 2005). As a consequence, leaf yellowing can reduce the overall display life of selected *Alstroemeria* cultivars. Several treatments have been tested for their ability to delay leaf yellowing and thereby extend the vase life of *Alstroemeria* cut flowers.

It is reported that vase life of many cut flowers can be extended by treatment with cytokinins (Nowak et al. 1990). Pulse treatment with 25 and 50 mg L^{-1} benzyladenine (BA) delayed ethylene production and extended

the vase life of cut *Eustoma* flowers (Hassanpour & Karimi 2010). Treatment with the commercial BA-containing formulation, Accel, at 25 mg/L BA equivalent consistently increased the number of days to full opening of primary florets and delayed the onset of flower senescence and leaf yellowing of *Alstroemeria* cut flowers (Mutui et al. 2001). It was found that 0.05 mg L^{-1} BA could delay the change in fresh weight, respiration rate and water uptake of gerbera (Kittisiripat & Techawongstien 2007). Also BA have been particularly effective in delaying leaf senescence and prolonging vase life of cut Heliconia (Paull & Chantrachit 2001), Lilium (Han 2001) and Eustoma (Huang & Chen 2002). Researchers suggested that the effect of BA on the extension of vase life depended upon flower or inflorescence type, season of harvest and cultivar (Paull & Chantrachit 2001).

Thidiazuron (TDZ, *N*-phenyl-*N*_-1,2,3-thiadiazol-5- ylurea) is a substituted phenylurea compound that has high cytokinin-like activity that probably is the basis of its herbicidal and defoliation properties (Ferrante et al. 2002). Ferrante et al. (2002) reported that a single 24-h pulse treatment with 10 µM TDZ retarded chlorophyll degradation and prevented yellowing of isolated leaves of cut flowers of *Alstroemeria* for more than 2 months. TDZ also delayed the onset of leaf senescence in tulips, Chrysanthemums (Ferrante et al. 2003) and *Pelargonium* (Mutui et al. 2005). But TDZ in combination with sucrose, were more effective in delaying senescence of cut inflorescences of phlox and *Lupinus* and greatly improved overall postharvest display life (Sankhla et al. 2005a,b). In addition Macnish et al. (2010) demonstrated that a postharvest pulse with 0.2–1mM TDZ for 6–24 h extended the vase life of iris flowers.

Alstroemeria cv. Setpoint with red petals and 6-8 average flowers per stem is a high productivity cut flower. But as the most *Alstroemeria* cultivars early leaf yellowing of cv. Setpoint is the major post harvest problem.

The objective of the current research was to determine the effect of TDZ and BA in combination with sucrose and hydroxyquinoline sulfate (8-HQS), as an antimicrobial compound, on postharvest characteristics of *Alstroemeria* cv. Setpoint cut flowers. Pulse treatment with these combinations may be more useful for preventing leaf yellowing and extending vase life of *Alstroemeria* cv. Setpoint cut flowers.

MATERIALS AND METHODS

Plant materials

Cut *Alstroemeria* flowers cv. Setpoint were harvested at commercial maturity (oldest buds about to open) and were transported dry to the laboratory of Horticultural

Sciences at University of Guilan, within 6 h. Stems were cut to 45 cm and placed into vases containing solutions. Vases were then placed into a controlled environment room at 22±2 °C, 70% RH and 750-800 lux light intensity for 10 h day^{-1} by cool-white fluorescent lamps.

Pulse treatments

Flowers were 'pulse' treated for 24 h with solutions containing 10 g L^{-1} sucrose (S1), 30 g L^{-1} sucrose (S2), 10 µM TDZ, 0.1 mM BA and 200 mg L^{-1} hydroxyquinoline sulfate (8-HQS) with mentioned combinations in Table 1. After pulse treatment of cut stems under the conditions described above, all flowers were placed in deionised water and postharvest performance was compared with that of control flowers. This experiment was conducted in completely randomized design with three replications while three stems were used for each replication. Results were analyzed by using SAS software. Mean comparisons to identify significant differences between treatments were performed using least significant difference (LSD).

Vase life parameters

Vase life was judged as the time (days) to 50% visible leaf yellowing and/or 50% petal abscission relative to the initial number of leaves and flowers on each replicate stem (Mutui et al. 2001).

Fresh weight

Relative fresh weight of cut flowers was calculated using the formula: RFW (%) = $(W_t/W_{t=0}) \times 100$; where W_t = weight of cut flowers (g) at t = days 2, 4, 6, 8, 10, 12, 14, 16 and18. $W_{t=1}$ = weight of the same cut flower (g) on day 1 (He et al. 2006).

Water uptake

Vase water uptake was determined using the formula: Water uptake (ml day^{-1} g^{-1} fresh weight) = $(S_{t-1}-S_t)/W_t$; where, S_t = solution weight (g) at t = days 4, 6, 8, 10, 12, 14, 16 and 18. St-1 = solution weight (g) on the preceding day, and W_t = fresh weight of the cut flower (g) on t days (He et al. 2006).

Chlorophyll determination

a. At the last vase life day of control flowers (day 16) the chlorophyll content of fully expanded leaves from cut flower stems were extracted with acetone and ethyl ether by Wu et al. (1969) method. The extinction point was quantified with a spectrophotometer (6405. UV/Vis – JENWAY-England) by absorption at 645 and 663 nm and used following equations for quantification of the total chlorophyll content:

Chlorophyll a+b (mg/g f.w) = 0.0202 (A_{645}) + 0.00802 (A_{663})

b. Leaf chlorophyll changes was measured by using (Spad- 502, Mirolta co.) in different days 2, 4, 6, 8, 10, 12, 14, 16 and18 during experiment time.

Table 1. Effect of pulse treatments on postharvest investigated factors of *Alstroemeria* cut flowers cv. Setpoint*

Treatment		Total means						
		Leaf Yellowing (day)	Petal abscission (day)	Fresh weight (% of initial value)	Water uptake (ml gf.w $^{-1}$)	Chlorophyll a+b on day 16 (mg gf.w^{-1})	Chlorophyll SPAD (% of initial value)	Total soluble solids (%)
S1	0	12.6d	15.7d	100.77ef	0.29f	0.0210g	78.11g	2.63f
	BA	32.5bc	16.3abcd	104.67bc	0.31def	0.0276de	86.78de	3.58c
	TDZ	34.9ab	16.8abcd	107.72a	0.32de	0.0309c	90.41bcd	3.72bc
	8-HQS	11.8d	15.5d	101.62de	0.33d	0.0200g	79.93fg	2.73ef
	BA+8-HQS	35.8ab	16.2bcd	104.90bc	0.37ab	0.0287cd	88.16cde	3.63bc
	TDZ+8-HQS	36.4ab	18.4ab	107.69a	0.37ab	0.0346ab	94.03ab	3.78abc
S2	0	12.0d	15.9cd	100.11ef	0.29ef	0.0200g	75.82g	3.02d
	BA	30.0c	16.4abcd	104.76bc	0.34bcd	0.0231fg	83.69ef	3.70bc
	TDZ	35.7ab	18.0abc	106.23ab	0.34bcd	0.0316bc	92.45abc	3.88ab
	8-HQS	12.2d	16.0cd	103.39cd	0.33d	0.0200g	77.53g	2.98de
	BA+8-HQS	35.0ab	16.0cd	104.65bc	0.38a	0.0249ef	86.11de	3.78abc
	TDZ+8-HQS	36.9a	18.6a	108.20a	0.39a	0.0360a	95.61a	4.03a
Deionised water (control)		11.2d	15.3d	98.74f	0.25g	0.0160h	69.86h	2.51f
LSD		4.267	2.367	2.389	0.272	0.003	4.706	0.031

*Data are means of 3 replicates. Means followed by the same letter within a column are not significantly different according to the LSD test ($P < 0.05$).

Total soluble solids

Total soluble solids (TSS) were determined in petals of flowers (g/100 g FW). Petals (3 g) were crushed in a mortar then filtered through cotton. Total soluble solids were measured by a table-type (CETI BELGIUM model) refractometer at = days 1, 6 and 15.

RESULTS

Leaf yellowing

Incorporation of TDZ and BA in the pulsing solution considerably delayed the onset of leaf yellowing. Combination of BA with 10 g L^{-1} sucrose was more effective on delaying leaf yellowing than BA with 30 g L^{-1} sucrose while TDZ in combination with 30 g L^{-1} sucrose resulted in the longest retardation in leaf yellowing (Table 1). Pulse treatment with S2+TDZ+8-HQS significantly increased the mean number of days to leaf yellowing (25.7 days) in comparison to untreated control flowers. There were no significant ($p<0.05$) differences between this treatment and other treatments containing TDZ (Table 1).

Petal abscission

The effect of treatments on extending time to petal abscission was not as considerable as leaf yellowing. Among all tested treatments, combination of S2+TDZ+8-HQS caused to extend flower longevity just 3.3 day more than untreated control flowers (Table 1). This treatment had no significant ($p<0.05$) difference with the other treatments containing TDZ. Treatments containing BA had no significant ($p<0.05$) effect on delaying time to petal abscission in comparison with control flowers (Table 1).

Fresh weight

Maximum relative fresh weight was specifically associated with flowers treated with TDZ in combination with S2 and 8-HQS (Table 1). The means of fresh weight of this treatment increased at the first days until day 10 and after that decreased on following days so that on day 18 it was 88.71 % of initial value (Fig. 1B). However, there were no significant ($p<0.05$) differences among all the TDZ containing treatments. Minimum relative fresh weight was associated with untreated flowers (Table 1). There was a little increase in control flowers until day 4 and after that it decreased more rapidly than other treatments so that on day 18 it was 74.73 % of initial value with no significant differences with both S1 and S2 treatments (Fig. 1A,B).

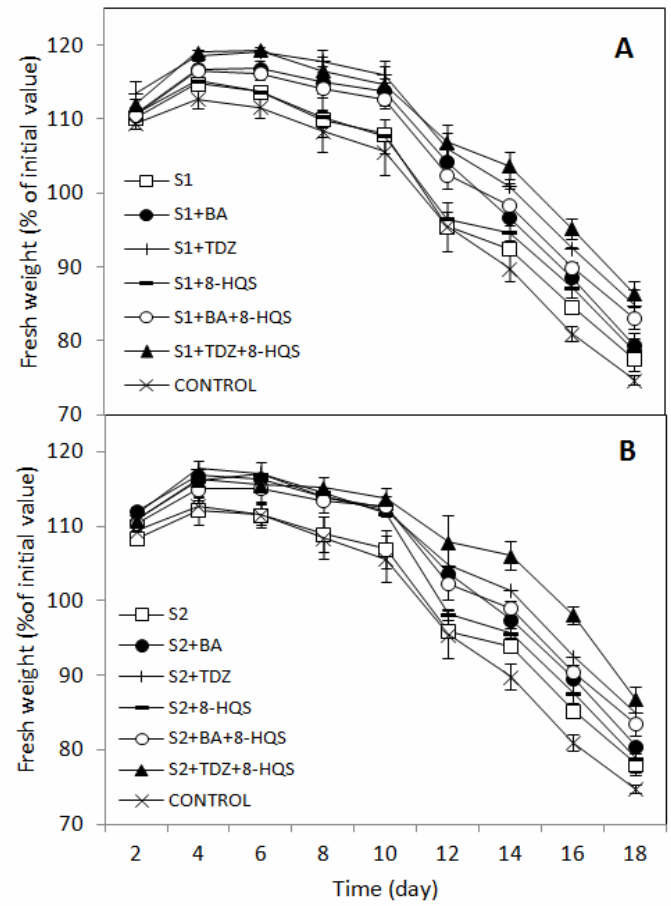

Figure 1. Effect of 24 h pulse treatments with A) 10 g L^{-1} sucrose (S1) in combination with 10 µM TDZ, 0.1 mM BA and 200 mg L^{-1} 8-HQS and deionized water (control) and B) 30 g L^{-1} sucrose (S2) in combination with 10 µM TDZ, 0.1 mM BA and 200 mg L^{-1} 8-HQS and deionized water (control) on changes in fresh weight of *Alstroemeria* cut flowers cv. Setpoint. Values are the means of 3 replications, ± S.E.

Water uptake

All treatments significantly increased water uptake compared with the control (Table 1). Water uptake rate decreased from day 4 in all treatments, but this decrease was more rapid in control and followed by S1 and S2 (Fig. 2A,B). Adding 8-HQS and TDZ to S2 caused maximum water uptake in all

days (Fig. 2B).

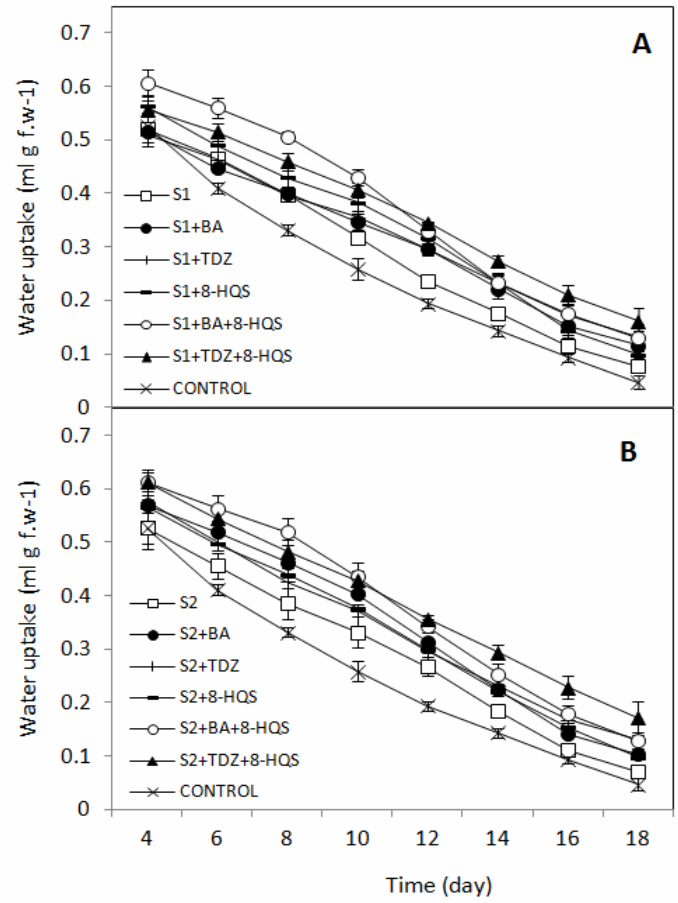

Figure 2. Effect of 24 h pulse treatments with A) 10 g L^{-1} sucrose (S1) in combination with 10 µM TDZ, 0.1 mM BA and 200 mg L^{-1} 8-HQS and deionized water (control) and B) 30 g L^{-1} sucrose (S2) in combination with 10 µM TDZ, 0.1 mM BA and 200 mg L^{-1} 8-HQS and deionized water (control) on changes in water uptake of *Alstroemeria* cut flowers cv. Setpoint. Values are the means of 3 replications, ± S.E.

Chlorophyll content

Chlorophyll a+b

It is noticeable that there were significant ($p<0.05$) differences between all

treatments and control at day 16 and treatments containing TDZ resulted in more chlorophyll content than the other treatments (Table 1). Results that obtained by spectrophotometer showed that flowers treated with combination of S2+TDZ+8-HQS significantly had more leaf chlorophyll content in comparison to untreated control. While effect of BA with 30 g L^{-1} sucrose on delaying chlorophyll degradation was significantly less than BA with 10 g L^{-1} sucrose (Table 1).

Chlorophyll measured by SPAD

Using the chlorophyll meter SPAD-502 provided simple and real estimation of changes in leaves chlorophyll contents. Leaf chlorophyll content increased at the first days of experiment and then decreased in all treatments from day 4 except treatments containing TDZ that had higher amount of chlorophyll than initial value until day 6. Furthermore, rate of decreasing chlorophyll was different between treatments. Chlorophyll content decreased rapidly in control and then S1 and S2, while flowers were treated by TDZ showed the minimum decrease until the end of vase life (Fig. 3A,B).

Total soluble solids

Total soluble solids of petals decreased during the experiment, but these changes were not similar between different treatments. At day 6, amounts of total soluble solids of petals treated with solution containing TDZ or BA in both concentrations of sucrose was more than value on one day after harvest (Fig. 4A,B). In other treatments, total soluble solids of petals decreased rapidly. The most total soluble solids of petals (4.03 %) was related to S2+TDZ+8-HQS treatment during the experiment and the least total soluble solids of petals was related to untreated control flowers (2.51 %) that it had no significant difference with S1 and S1+8-HQS (Table 1).

DISCUSSION

Leaf yellowing of *Alstroemeria* cv. Setpoint cut flowers occurred before the flower senescence, within 9-11 days after harvest. In this study 13 solutions were tested to prolong the vase life of 'Setpoint' cut flowers. The combination of 30 g L^{-1} sucrose + 10 µM thidiazuron + 200 mg L^{-1} hydroxyquinoline sulfate could successfully extend flower vase life and improve postharvest quality of the flowers. Findings were obtained by Ferrante et al. (2002) showed that TDZ could not extend flower longevity of *Alstroemeria* cut flowers, but in this experiment treating *Alstroemeria* cut flowers with 10 µM thidiazuron in combination with 30 g L^{-1} sucrose and 200 mg L^{-1} hy-

droxyquinoline sulfate delayed time to petal abscission (3.3 days) compared with untreated control flowers.

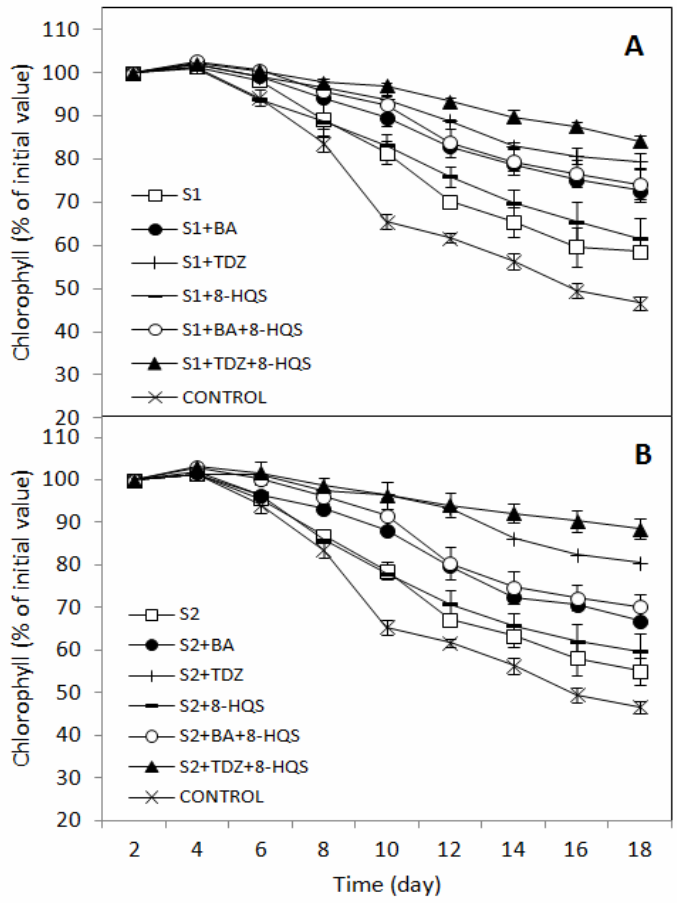

Figure 3. Changes in Chlorophyll (SPAD reading) of *Alstroemeria* cut flowers cv. Setpoint, A) treated by 10 g L^{-1} sucrose (S1) in combination with 10 µM TDZ, 0.1 mM BA and 200 mg L^{-1} 8-HQS and deionized water (control) and B) treated by 30 g L^{-1} sucrose (S2) in combination with 10 µM TDZ, 0.1 mM BA and 200 mg L^{-1} 8-HQS and deionized water (control) for 24 h. Values are the means of 3 replications, ± S.E.

Previous studies showed that TDZ is able to inhibit carotenoid degradation and retard chlorophyll degradation (Ferrante et al. 2002, Ferrante et al.

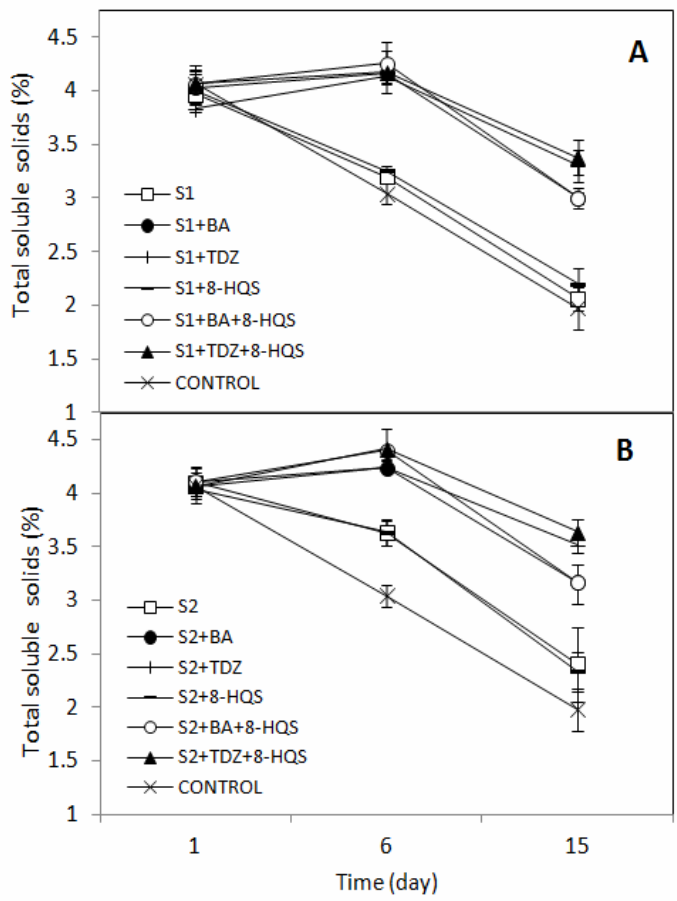

Figure 4. Changes in total soluble solids of petal of *Alstroemeria* cut flowers cv. Setpoint, A) treated by 10 g L^{-1} sucrose (S1) in combination with 10 µM TDZ, 0.1 mM BA and 200 mg L^{-1} 8-HQS and deionized water (control) and B) treated by 30 g L^{-1} sucrose (S2) in combination with 10 µM TDZ, 0.1 mM BA and 200 mg L^{-1} 8-HQS and deionized water (control) for 24 h. Values are the means of 3 replications, ± S.E.

2003, Ferrante et al. 2004). In addition its cytokinin-like activity, TDZ may also play a role in modulating the effects of ethylene in cut flowers (Sankhla et al. 2005b). The overall trend of changes in leaf chlorophyll contents by SPAD showed that flowers treated with TDZ had higher level of chlorophyll contents and generally, rate of chlorophyll degradation was slower than

flowers treated with BA in all days of experiment. External applications of BA had been effective on retarding senescence of various cut flowers by arresting degradation of protein and chlorophyll (Mutui et al. 2001) and TDZ, is so effective at inducing cytokinin-like responses (Ferrante et al. 2002). Probably the effect of TDZ on delay leaf yellowing is due to its cytokinin-like activity that is higher than BA. TDZ is not metabolized by the plants therefore its activity lasts longer than BA (Ferrante et al. 2009).

In the present study combination of 30 g L^{-1} sucrose + 10 µM thidiazuron with 200 mg L^{-1} hydroxyquinoline sulfate resulted to increase leaf chlorophyll content due to improve uptake of solution containing TDZ. Hydroxyquinoline sulfate is a bactericide and acidifying agent that inhibits microorganism activity and so vascular occlusion in the cut flowers stems (Nowak et al. 1990, Skutnik et al. 2004). Application of 30 g L^{-1} sucrose resulted in less chlorophyll content compared to 10 g L^{-1} sucrose. This response was even greater for stems treated in combination with sucrose and BA. However there was no significant difference between two sucrose concentrations in most cases. According to previous reports increasing sucrose concentration can induce leaf yellowing (Chanasut et al. 2003, Wingler et al. 1998) and probably high concentration of sucrose was effective on cytokinin activity.

Although it has been reported that treating cut flowers with exogenous sucrose extends the cut flowers longevity and increase content of soluble carbohydrates (Chanasut et al. 2003, Eason et al. 1997, Ichimura et al. 2003), but in this experiment sucrose even in concentration 30 g L^{-1} without TDZ or BA had slightly effect on vase life and total soluble solids of *Alstroemeia* cut flowers. Accordingly the main reason of increasing total soluble solids of petal was presence of TDZ and BA in pulsing solutions. Cytokinins are able to delay age-dependent decline of enzymes involved in photosynthetic and so enhance photosynthesis (Wingler et al. 1998) and promote carbohydrate metabolism (Mutui et al. 2001). Significant difference between TDZ and BA was attributed to having cytokinin-like activity and stability in plant tissues (Ferrante et al. 2002, Chamani et al. 2006). On the other hand sucrose reducing water loss by induces stomatal closure in the leaves. Also, sucrose extends the longevity of cut flowers by increasing fresh weight and carbohydrates supplement in floral tissue for metabolism and maintaining the respirable substrates in flowers (Eason et al. 1997, Ichimura et al. 1999, Ichimura et al. 2003, van Doorn 2001).

Application of 8-HQS significantly increased water uptake and fresh weight. 8-HQS extended the vase life of *Alstroemeria* cut flowers, presumably by preventing the accumulation of microorganisms in xylem vessels (Ichimura et al. 1999, Knee 2000) and maintenance of the hydraulic

conductance of stem (Ichimura et al. 1999). Furthermore TDZ prolonged vase life of cut *Alstroemeria* flowers by retarding fresh weight loss and increasing water uptake that previously reported in some other studies (Chamani et al. 2006, Ferrante et al. 2005).

CONCLUSION

Results of this study suggest that, BA was able to prolong vase life of *Alstroemeria* cut flowers cv. Setpoint, but effect of TDZ was significantly more. TDZ was known to ineffective to extend time to petal abscission in *Alstroemeria* cut flowers, but in this study TDZ in combination with sucrose and 8-HQS not only reduced leaf yellowing but also delayed onset of petal abscission. Also this combination positively affected total soluble solids of petals, fresh weight and water uptake. However, more studies are necessary to determine the effect of TDZ alone or in combination with the other materials.

REFERENCES

Chamani, E., Irving, D.E., Joyce, D.C., Arshad, M. (2006): Studies with thidiazuron on the vase life of cut rose flowers. Journal of Applied Horticulture 8: 42-44.

Chanasut, U., Rogers, H.J., Leverenttz, M.K., Griffiths, G., Thomas, B., Wagstaff, C., Stead, A.D. (2003): Increasing flower longevity in Alstroemeria. Postharvest Biology and Technology 29: 324-332.

Eason, J.R., de Vre, L.A., Somerfield, S.D., Heyes, J.A. (1997): Physiological changes associated with *Sandersonia aurantica* flower senescence in response to sugar. Postharvest Biology and Technology 12: 43-50.

Ferrante, A., Hunter, D.A., Hackett, W.P., Reid, M.S. (2002): Thidiazuron-a potent inhibitor of leaf senescence in Alstroemeria. Postharvest Biology and Technology 25: 333-338.

Ferrante, A., Tognoni, F., Mensuali-Sodi, A., Serra, G. (2003): Treatment whit thidiazuron for preventing leaf yellowing in cut tulips and chrysanthemum. Acta Horticulturae 624: 357-363.

Ferrante, A., Vernieri, P., Serra, G., Tognoni, F. (2004): Changes in Abscisic acid during leaf yellowing of cut stock flowers. Journal of Plant Growth Regulation 43: 127-134.

Ferrante, A., Mensuali-sodi, A., Tognoni, F., Serra, G. (2005): Postharvest studies on leaf yellowing of chrysanthemum cut flowers. Advances in Horticultural Science 19: 81-82.

Ferrante, A., Mensuali-Sodi, A., Serra, G. (2009): Effect of thidiazuron and gibberellic acid on leaf yellowing of cut stock flowers. Central European Journal of Biology 4: 461–468.

Han, S.S. (2001): Benzyladenine and gibberellins improve postharvest quality of cut Asiatic and oriental lilies. HortScience 36: 741-745.

Hassanpour Asil, M., Karimi, M. (2010): Efficiency of benzyladenine reduced ethylene production and extended vase life of cut *Eustoma* flowers. Plant Omics Journal 3: 199-203.

He, S., Joyce, D.C., Irving, D.E. (2006): Competition for water between inflorescences and leaves in cut flowering stems of *Grevillea* 'Crimson Yul-lo'. Journal of Horticultural Science and Biotechnology 81**:** 891–897

Huang, K.L., Chen, W.S. (2002): BA and sucrose increase vase life of cut Eustoma flowers. HortScience 37: 547-549.

Ichimura, K., Kojima, K., Rie, G. (1999): Effect of temperature, 8-hydroxyquinoline sulphate and sucrose on vase life of cut rose flowers. Postharvest Biology and Technology 15: 33-40.

Ichimura, K., Kawabata, Y., Kishimoto, M., Goto, R., Yamada, K. (2003): Shortage of soluble carbohydrates is largely responsible for short vase life of cut 'Sonia' rose flowers. Journal of the Japanese Society for Horticultural Science 72: 292-298.

Kittisiripat, W., Techawongstien, S. (2007): Effect of benzyladenine on vase life of Gerbera (*Gerbera jamesonii*) 'Florijn'. Agricultural Science Journal 38: 103-106.

Knee, M. (2000): Selection of biocides for use in flolar presevatives. Postharvest Biology and Technology 18: 227-234.

Macnish, A.J., Jiang, C.Z., Reid, M.S. (2010): Treatment with thidiazuron improves opening and vase life of iris flowers. Postharvest Biology and Technology 56: 77–84

Mutui, T.M., Emongor, V.E., Hutchinson, M.J. (2001): Effect of Accel on the vase life and postharvest quality of (*Alstroemeria aurantiaca* L.) cut flowers. African Journal of Science and Technology 2: 82-88.

Mutui, T.M., Mibus, H., Serek, M. (2005): Effects of thidiazuron, ethylene, abscisic acid and dark storage on leaf yellowing and rooting of Pelargonium cuttings. Journal Of Horticultural Science & Biotechnology 80: 543-550

Nowak, J., Rudnicki, R.M., Duncan, A.A. (1990): Post harvest handling and storage of cut flowers, florist greens and potted plants. Timber Press, Seattle, 210 pp.

Paull, R., Chantrachit, T. (2001): Benzyladenine and the vase life of tropical ornamentals. Postharvest Biology and Technology 21: 303-310.

Sankhla, N., Mackey, W.A., Davis, T.D. (2005a): Corolla abscission and petal color in cut phlox flower heads: Effect of sucrose and thidiazuron. Acta Horticulturae 669: 389-394.

Sankhla, N., Mackey, W.A., Davis, T.D. (2005b): Effect of thidiazuron on senescence of flowers in cut inflorescence of Lupinus densiflorus benth. Acta Horticulturae 669: 239-244.

Skutnik, E., Rabiza-wider, J., Wachowicz, M., Łukaszewska, A.J. (2004): Senescence of cut leaves of *Zantedeschia aethiopica* and *Z. elliottiana*. Part III. The reducing sugars content. Acta Scientiarum Polonorum, Hortorum Cultus 3: 219-227.

van Doorn, W.G. (2001): Role of soluble carbohydrates in flower senescence: a survey. Acta Horticulturae 543: 179-183.

Wingler, A., van Schaewen, A., Leegood R.C., Lea, P.J., Quick, P. (1998): Regulation of leaf senescence by cytokinin, sugars and light. Journal of Plant Physiology 116: 329-335.

Wu, L., Wu, R.Y., Li, H.W., Chu, P.N. (1969): Influence of white leaf disease of sugarcane on the chloroplast development and chlorophyll biosynthesis. Botanical Bulletin of Academia Sinica 10: 23-28.