

Carnation Flowers Senescence as Influenced by Nickel, Cobalt and Silicon

Babak Jamali* and Majid Rahemi

¹Department of Horticultural Science, College of Agriculture, Shiraz University, Shiraz, IRAN

ABSTRACT

Ethylene acts as a limiting factor for commercial carnation production which can decrease the vase life and postharvest quality. Use of ethylene production inhibitors such as nickel (Ni) or cobalt (Co) may keep the flowers quality for longer period also beneficial elements such as silicone (Si) might possess positive impact on postharvest life of cut flowers of carnations with climacteric respiration. To evaluate the effect of these three elements a completely randomized designed study was carried out, there were 3 replications each of which had 3 'Harlem' carnation flowers. They were put in 500 mL vases which had been filled with 400 mL distilled water for the control treatment and 400 mL solution of the following concentrations: NiSO₄ (30, 45, 60 mg.L⁻¹) CoCl₂ (50, 75, 100 mg.L⁻¹) and K₂SiO₃ (100, 150, 200 mg.L⁻¹). All elements caused higher vase life and lower ethylene production. Further investigation with other cultivars seems useful.

Keywords: essential element-ethylene inhibitor-growth and development

INTRODUCTION

Ethylene production by carnation flowers (*Dianthus caryophyllus* L.) is known to be associated with rise of respiration rate and onset of senescence, so it is considered as a limiting factor of carnation production (Whitehood et al. 1984, Badiyan et al, 2004). Lowering this phenomenon, can be an effective mean for prolonging the vase life and longevity of carnation flowers (Podd and VanStaden 1999). Regarding this fact, application of ethylene blocking agents has been used to extend the vase life of carnation (Brandt and Woodson 1992, Goszczynska 2003). Silicon (Si) is the second most abundant element of the earth's surface. Numerous laboratory, greenhouse and field experiments have shown benefits of Si application on different aspects of plant growth such as root development, fruit formation, crop yield and postharvest quality parameters (Snyder et al. 2007). Nickel (Ni) as an essential element, plays different roles in completion of plant life cycle (Wood and Reilly 2007). It has been demonstrated that this element has anti-ethylene features and can impede its production (Smith and Woodburn 1984, Zheng et al. 2006). The similar characteristic has been mentioned for cobalt (Co) (Lau and Yang 1976). The aim of this study was to evaluate postharvest life prosperities of carnation flowers as influences by Co, Ni and Si.

MATERIALS AND METHODS

Cut flowers of carnation cv. Harlem that had been harvested at the anthesis in the morning and bought in local market were transported to laboratory in the afternoon. Stems were cut to 45 cm under water, the leaves were eliminated till nod 6, then put in 500 mL vases which had been filled with 400 mL distilled water for the control treatment and 400 mL solution of the following concentrations: NiSO₄ (30, 45, 60 mg.L⁻¹) CoCl₂ (50, 75, 100 mg.L⁻¹) and K₂SiO₃ (100, 150, 200 mg.L⁻¹). The flowers were put in artificial longday (by using florescent lamps) condition (16h of light and 8h of darkness). Temperature and RH were about 24° C and 50% respectively. The experiment was done in a completely randomized design with 3 replications each of which had three flowers as experimental units.

For the purpose of measuring ethylene production, 5 similar-sized petals were weighted then enclosed in 30 mL glass vials for 1 hour and 3 mL gas sample from head space was withdrawn for analysis. The amount of ethylene was determined by gas chromatography: gas chromatograph, Porapak, Q, GC-14B Shimadzu, Japan. Ethylene production of flowers was measured every 24 hours after the start of research and was expressed reported as nL per gram fresh weight per hour. The vase life of flowers was measured by calculating the hours from study commencement moment till appearance of the petal-in-rolling or petal discoloration. The total soluble carbohydrates was measured according to McCready et al. (1950) and expressed as mg g⁻¹ dry weight. Flowers were weighted every day for determining fresh weight and results were expressed as percent of initial value. At the end of experiment flowers were oven dried at 70° C for 3 days in order to measure their dry weight and expressed as g. Data were analyzed by SPSS 16 software and the means were compared using Duncan's test.

* Corresponding author: babakjamali@ymail.com

RESULTS

In all treatments, the vase life was significantly higher than control samples and 45 mg. L⁻¹ of Ni solution and 300 mg. L⁻¹ of Si solution were able to maintain the quality of flowers for about 1 more day when compared with control. The highest dry weight of flowers was obtained from flowers that received 45 mg. L⁻¹ of Ni and 150 or 300 mg. L⁻¹ of Si solution. Control samples, and flowers treated with 50 and 75 mg. L⁻¹ of Co solution had the highest total soluble carbohydrates. Starch content of flowers was significantly higher than control when Ni or Si solution was utilized as indicated in Table 1.

Table 1. The effect of Ni, Co and Si on vase life, dry weight and total soluble carbohydrates.

Treatment (mg. L ⁻¹)	Vaselife (h)	Dry weight (g)	Total soluble carbohydrates (mg. g ⁻¹ DW)
Control ^z	173.28 f*	6.33 cde	35.21 a
Ni 30	188.75 c	6.27 cde	33.19 c
Ni 45	193.22 ab	6.73 ab	32.21 cd
Ni 60	192.18 b	6.46 cd	33.40 bc
Co 50	176.65 e	5.93 f	35.12 a
Co 75	179.43 e	6.12 ef	34.89 ab
Co 100	184.88 d	6.22 de	32.25 cd
Si 100	177.21 e	6.50 bc	30.18 e
Si 150	185.57 d	6.80 a	31.02 de
Si 300	195.28 a	6.77 a	29.77 e

^z Means followed by same letter are not significantly different at 5% probability using Duncan's test.

The rate of fresh weight loss decreased after treatments application specially the final days of experiment had significantly lower rate of fresh weight loss (Figure 1, 2 and 3). Ethylene production rate and also the peak, decreased significantly after application of 60 mg. L⁻¹ of Ni, 100 mg. L⁻¹ of Co and 300 mg. L⁻¹ of Si solution as presented in Figure 4, 5 and 6.

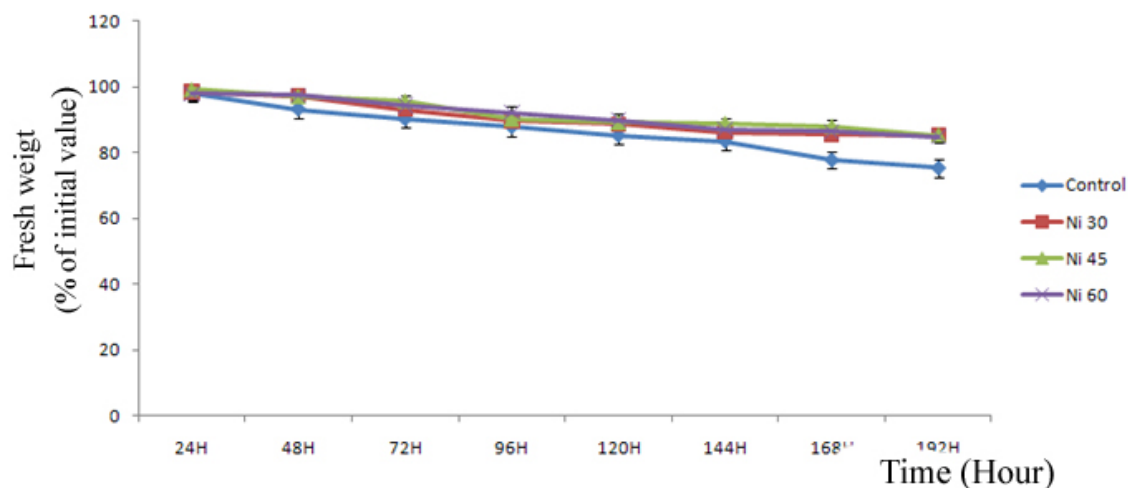


Figure 1. Fresh weight of cut flowers of 'Harlem' carnation treated with Ni solution. Vertical bars indicate SE.

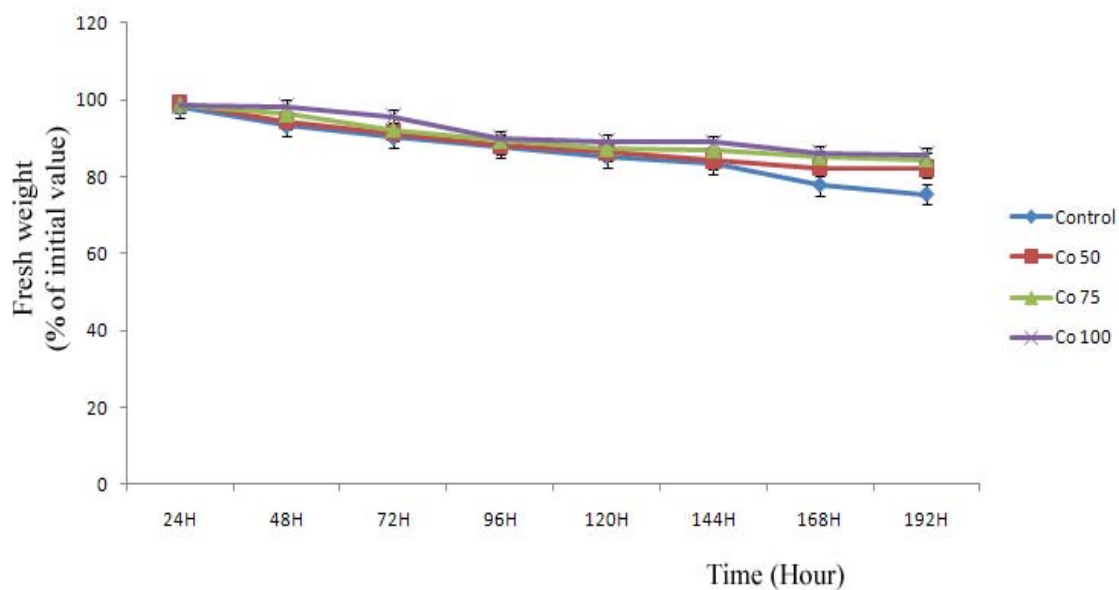


Figure 2. Fresh weight of cut floweres of 'Harlem' carnation treated with Co solution. Vertical bars indicate SE.

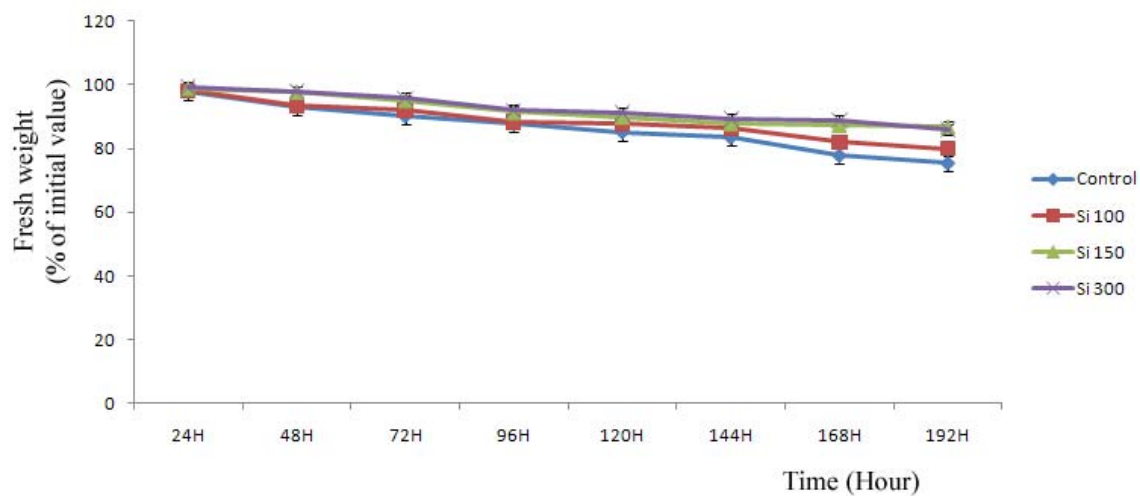


Figure 3. Fresh weight of cut floweres of 'Harlem' carnation treated with Si solution. Vertical bars indicate SE.

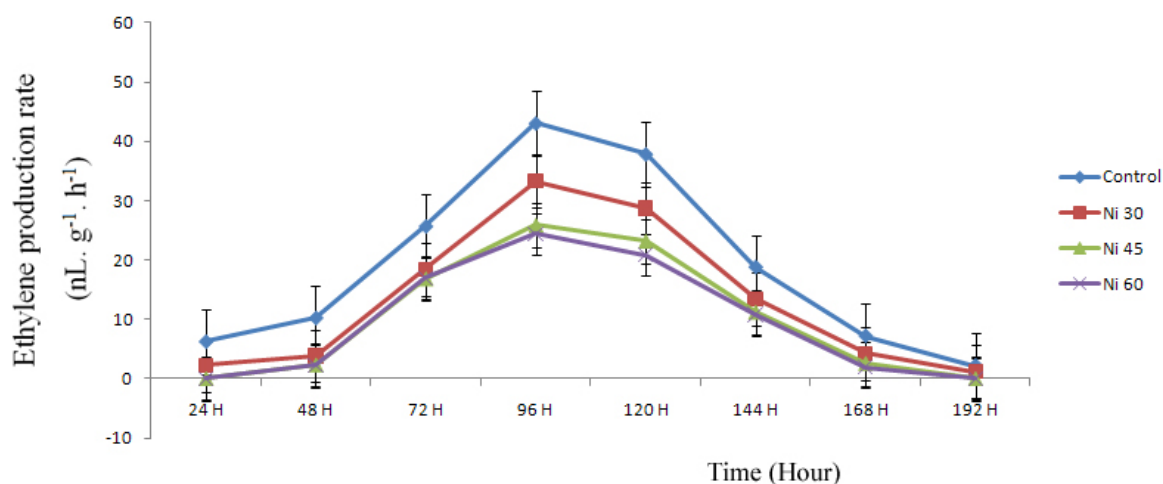


Figure 4. Ethylene production of petals of cut floweres of 'Harlem' carnation treated with Ni solution. Vertical bars indicate SE.

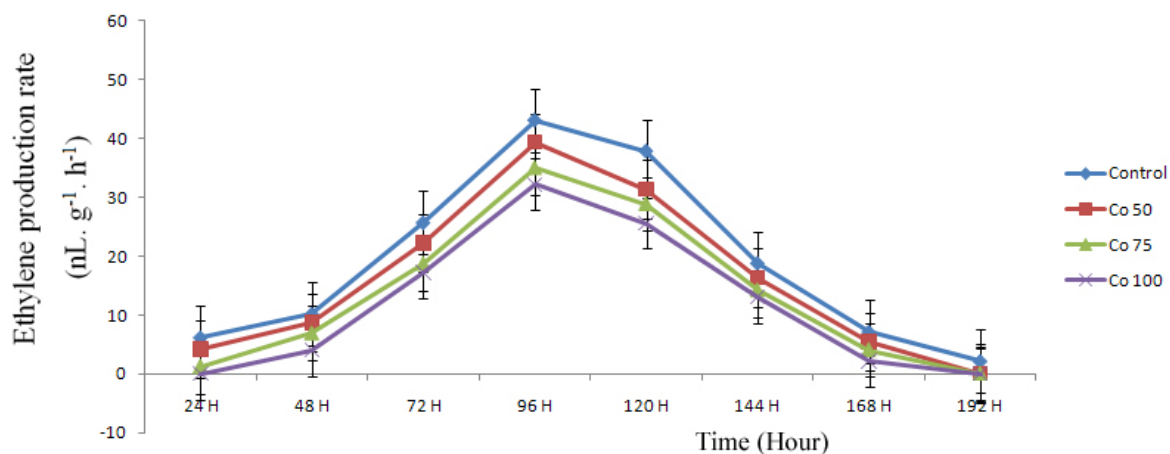


Figure 5. Ethylene production of petals of cut floweres of 'Harlem' carnation treated with Co solution. Vertical bars indicate SE.

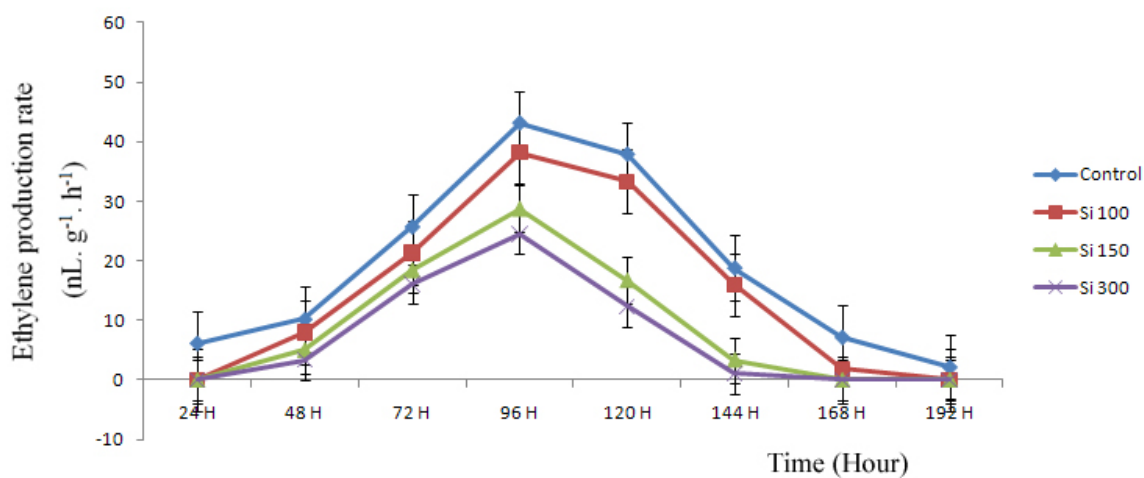


Figure 6. Ethylene production of petals of cut floweres of 'Harlem' carnation treated with Si solution. Vertical bars indicate SE.

DISCUSSION

Ethylene is a plant hormone the endogenous of which is associated with the process of senescence (Lieberman 1979, Woodson et al. 1993). Carnation is a typical ethylene sensitive flower. It has been well-documented that carnation flowers produce ethylene through an autocatalytic reaction to engender rapid flower senescence (Borchov and Woodson 1989, VanAltvorst and Bovy 1995). Pun et al (2001) reported that the vase life of carnation flowers can be extended by postponing autocatalytic ethylene production and in our study all three elements reduced this phenomenon and this diminution is in accordance with maintenance of quality parameters as it is indicated in table 1. Ni is the most recently element which is classified as essential for plant life cycle (Brown et al. 1987). Ions of Ni, have an inhibitory effect on ACC oxidase (the enzyme responsible for production of ethylene) by forming an enzyme-metal complex (Smith and Woodburn 1984). 0.1 % (W/V) solution of NiCl₂ was sprayed on 'Saijo' persimmon fruits twice before harvest which inhibited fruit softening effectively and prolonged the shelf life by delaying ethylene production (Zheng et al. 2006). Inhibitory effect of Ni on ethylene makes this element a good choice for improving the postharvest life of horticultural crops especially cut flowers because there is no concern about Ni accumulation at toxic levels in them, our findings are also in accordance with the mentioned facts. Lower total soluble carbohydrates observed in our study, is indication of a delay in senescence of flowers. On the other hand the nitrogen cycle within plants can be affected by Ni (Bai et al. 2006) and this element have beneficial influence on rigidity of protein structures (Wood and Reilly 2007), which might increase the total resistance of plants against senescence.

Although Co is not known to be definitely essential for higher plants, increment of shelf and vase life of marigold, chrysanthemum, rose and maidenhair fern has been reported after Co application, also this element has a long-lasting effect in preserving apple; the fruits are kept fresh by Co application after ripening (Talukder and Sharma 2007). Co can impede the production and accumulation of ethylene. This feature might be account for vase life augmentation, as it caused delay in senescence of lettuce by arresting the decline of chlorophyll, protein, RNA and to a lesser extend DNA. The activities of RNase and protease and tissue permeability were decreased while the activity of Catalase increased (Tosh *et al.*, 1979). Co utilization caused delay in aging of vetch (Merritt et al. 2001). Extending the shelf life of the fruits such as apple has been documented (Bulantseva et al. 2001). As it is indicated in table 1 and figure 5 our results are in accordance with what has just been mentioned.

Like Co, Si is not consider as an essential element for the plant growth and development, but it possesses beneficial impact on overall aspects of plant life (Snyder et al. 2007) such as suppressing biotic and abiotic stresses, crop yield increase and root development. Although there is no literature available that indicates an inhibitory effect of Si on ethylene but our findings imply a reduction in its production as shown in figure 6. The reason responsible for this might be interaction of this element with cellular membrane, as Hodson and Sangster (1988) reported that accumulated monosilicic acid polymerizes into polysilicic acid and then transforms to amorphous silica, which forms a thickened silicone-cellulose membrane, by this means, a double cuticular layer protects and mechanically strengthens plants. Si might also form complexes with organic compounds in the cell walls of epidermal cells, therefore increasing their resistance to degrading enzymes (Snyder et al. 2007). So it can be expected that when such treatments are utilized the senescence would be postponed and the postharvest characteristics would improve, which did occur in our study and when plants produce less ethylene, internal reservoir structures would maintain for longer period and this can be responsible for lower carbohydrates and higher dry weight of treated flowers.

REFERENCES

- Badiyan D, Wills RBH, and Bowyer M (2004). Use of nitric oxide donor compound to extend the vase life of cut flowers. *HortSci* 39: 1371-1372.
- Bai C, Reilly CC, and Wood BW (2006). Nickel deficiency disrupts metabolism of Ureides and amino acids of young pecan foliage. *Plant Physiol* 140: 433-443.
- Borchov A, and Woodson WR (1989). Physiology and biochemistry of flower petal senescence. *Hortic Rev* 11: 15-43
- Brandt AS, and Woodson WR (1992). Variation in flower senescence and ethylene biosynthesis among carnations. *HortSci* 27: 1100-1102.
- Brown, PH (2007). Nickel. In: *Handbook of Plant Nutrition*, (Eds.: AV Barker and DJ Pilbean (Eds),). CRC Taylor and Francis, New York, USA, pp. 395-402.
- Brown PH, Welch RM, and Carry EE (1987). Nickel: a micronutrient essential for higher plants. *Plant Physiol* 85: 801-803.
- Goszczynska, DM (2003). Effect of ethylene inhibitors on longevity of cut carnations and ethylene production by flowers. *J Fruit Ornament Plant Res* 11: 89-98.

- Hodson MJ, and Sangster AG (1988). Silica deposition in the influence bracts of wheat. Scanning electron microscopy and light microscopy. *Can J Bot* 66:829-837
- Lieberman M (1979). Biosynthesis and action of ethylene. *Ann Rev Plant Physiol* 30: 533-591.
- McCready MR, Guggolz J, Silveira V, and Owens SH (1950). Determination of starch and amylose in vegetables. *Ann Chem* 22: 1156-1158.
- Merritt F, Kemper A, and Tallman G (2001). Inhibitors of ethylene synthesis inhibit auxin-induced stomatal opening in epidermis detached from leaves of *Vicia faba*. *Plant Cell Physiol* 42: 223-230.
- Podd LA, and VanStaden J (1999). The use of acetaldehyde to control carnation flower longevity. *Plant Growth Regul* 28: 175-178.
- Pun, UK, Rowarth JS, and Dawson K (2001). The influence of exogenous acetaldehyde solution on vase life of two carnation cultivars in the absence or presence of exogenous ethylene. *Plant Growth Regul* 34: 267-272.
- Smith NG, and Woodburn J (1984). Nickel and ethylene involvement in the senescence of leaves and flowers. *Z Natur Wiss* 71(4): 210-211.
- Snyder, G.H., V.V. Martichenkov and L.E. Datnoff. 2007. Silicone. In: *Handbook of Plant Nutrition*, (Eds.: AV Barker and DJ Pilbean (Eds),). CRC Taylor and Francis, New York, USA, pp: 551-568.
- Talukder G, and Sharma A (2007). Cobalt. In: *Handbook of Plant Nutrition*, (Eds.: AV Barker and DJ Pilbean (Eds),). CRC Taylor and Francis, New York, USA, pp: 499-514.
- Tosh S, Choudhuri MA, and Chatterjee SK (1979). Retardation of lettuce leaf senescence by cobalt ions. *Indian J Exp Biol* 17: 1134-1136.
- VanAltvorst AC, and Bovy AG (1995) The role of ethylene in senescence of carnation flowers, a review. *Plant Growth Regul* 16:43-53.
- Whitehood CS, Halevy AH, and Reid MS (1984). Content of ethylene synthesis during development and senescence of carnation petals. *J Amer Soc Hort Sci* 109: 473-475.
- Wood BW, and Reilly CC (2007). Nickel and plant disease. In: *Mineral Nutrition and Plant Diseases*, (Eds.: LE Datnoff, WH Elmer, and DM Huber). APS press, Minneapolis, USA, pp. 351- 402.
- Woodson W, Brandt A, Itzhak H, and Larsan P (1993). Ethylene regulation and function of flower senescence related genes. In: *Cellular and Molecular Aspects of the Plant Hormone Ethylene*, (Eds.: J Pech, A Latche and C Balague). Academic publishers, USA. pp: 291-297.
- Zheng Q, Nakatsuka A, Matsumoto T, and Itamara H (2006). Preharvest nickel application to calyx of 'Saijo' persimmon fruit prolongs postharvest shelf-life. *Postharvest Biol. Tech.* 42(1): 98-103.