10.7251/AGSY1303275C

POSTHARVEST EVALUATION OF CUT "WHITE SIM" CARNATION FLOWERS

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Abstract

Two separated experiments were performed in order to evaluate the effects of different concentrations of silver nanoparticles, methanol extract of *Crambe orientalis* L. plant, S-carvone, Salisylic acid, Humic acid, Silver thiosulphate and ethylene on longevity and some quality characteristics of cut 'White Sime' carnation flowers (*Matthiola incana*) based on completely randomized design with 5 replication. These experiments were carried out in postharvest laboratory of Mohaghegh Ardabili University in 2011. The results of first experiment showed that ethylene reduced the vase life of flowers and STS at all concentrations blocked the ethylene effects and increased the longevity of carnation flowers. In second expriment, STS and nano-silver increased flower vase life, while Humic acid, S-carvon and *Crambe orientalis* L. extracts did not influence longevity of cut carnation flowers. However, the higher levels of *Crambe orientalis* L. extract positively influenced the RFW of flowers. The results also showed that flowers subjected to 0.25 and 0.5 mM of STS maintained solution uptake until the last day of experiment and showed higher rate compared to control and other treatments. Moreover, the lower concentration of STS was more efficient than higher ones even in flower subjected with 10 and 100 µl l^{-1} of ethylene.

Keywords: Fresh weight, Longevity, Postharvest, Solution uptake.

Introduction

Postharvest senescence is a major limitation to the marketing of many species of cut flowers and considerable effort has been devoted to developing postharvest treatments to extend the marketing period (Ichimura *et al*., 1998., Shimamura and Okabayashi, 1997). Carnation is a typical ethylene sensitive flower and the senescence of this flower (*Dianthus caryophyllus L*.) is accompanied by a marked increase in ethylene synthesis and a concomitant climacteric rise in respiration. The postharvest life of ethylene sensitive flowers can be considerably increased by silver thiosulfate (STS) treatment. For instant, pre-treatment of cut carnation flowers with silver thiosulfate complex (STS) prevents the climacteric rise in ethylene production and delays senescence of flowers (Yangkhamman, *et al*., 2005; Basiri *et al*, 2011). Also, silver thiosulphate competes with ethylene for the same site of action and therefore reduces the negative effect of ethylene (Nowak and Rudnicki, 1990). STS is known to suppress autocatalytic ethylene production by inhibition of ethylene action (Ichimura *et al*., 1998., Shimamura and Okabayashi, 1997).

Recently, finding new compounds for increasing the flower vase life without pollution risks to substitute with STS have been very important.

Salicylic acid has been tested for control of postharvest diseases. It has been shown that salicylic acid in concentrations of 100, 500, and 1000 ml/l-1 was effective in controlling at least four pathogens of orange [*Citrus sinensis* (L.) Osbeck] and potato (*Solanum tuberosum*

L.). Most of the research using salicylic acid is directed to induction of systemic acquired resistance (SAR) in hosts against the attack of pathogens (Capdeville *et al*., 2003).
The effects of some plant extracts have been evaluated on vase life of cut flowers. For instant, 25% of rosemary extract has extented vase life of cut carnation flowers *(Dianthus caryophyllus cv.* 'white librity) up to 24.6 days in laboratory conditions (Basiri et al., 2011).
Nanometer sized silver (Ag_+) particles (NS) are considered to more strongly inhibit bacteria and other microorganisms than Ag in various oxidation states; Ag^0, Ag^+, Ag^{2+} and Ag^{3+} (Furno *et al*., 2004). Usage of nano-silver compounds (NS) as a pulse and vase solution treatment for cut flowers is relatively new (Liu *et al*., 2009) and has demonstrated importance as an antibacterial agent (Morones *et al*., 2005). NS releases Ag^+ which has been reported to interact with cytoplasmic components and nucleic acids, to inhibit respiratory chain enzymes and to interfere with membrane permeability (Park *et al*., 2005).
S-carvone is a natural compound with anti-microbial activity which has been used to increase the vase life of some ornamental plants. Previously, the possitive effects of s-carvon on vase life, fresh weight and solution uptake of some cut flowers such as *Baeckea frutescens* have been reported (Damunupola *et al*, 2010).
Humic acid is a natural organic polymer which is produced as a result of degradation of soil organic material such as peat and lignin. In many systems, humic substances behave similarly to cytokine's.
The purpose of this study was to evaluate the physiological effects of different compounds used to formulate preservatives solutions for floral stems conservation and their influence in the postharvest quality of cut carnation flowers.

Material and methods

Plant material
Cut carnation flowers (*Dianthus caryophyllus cv.* "*Wihte Sim*") were obtained from a commercial greenhouse (Tehran) at the commercial stage and transported to the postharvest laboratory of Mohaghegh Ardabili University, Ardabil. Two different experiments at two different times were conducted to evaluate the postharvest characteristics of cut carnation flowers.
First experiment
Flowers were pulse treated with different concentrations of silver thiosulfate (0.5, 1 and 2 mM), S-carvon (0.3, 0.6 and 1.2 mM), Salicylic acid (0.5, 1, 1.5 and 2 mM), Humic acid (10, 100, 500 and 1000 mg/l^{-1}), Nano-silver (10, 20, 50 and 100 mg/l^{-1}), extract of *Crambe orientalis* L. (10, 50, 100 and 500 mg/l^{-1}) and ethylene (1, 10 and 100 $\mu l/l^{-1}$) for 24h at 22°C. Deionized water used as a control at the same condition.

Second experiment
First part: To confirm the results of first experiment and also to find exact effective concentrations of various compound, flowers were pulse treated with different concentrations of silver thiosulfate (0.25, 0.5, 0.75, 1, 1.5 and 2 mM), S-carvon (0.3, 0.6 and 1.2 mM), Salicylic acid (1, 1.5 and 2 mM), Humic acid (10, 100, 500 and 1000 mg/l^{-1}), Nano-silver (10, 20, 50 and 100 mg/l^{-1}) and extract of *Crambe orientalis* L. (B) (10, 50, 100, 500 and 750 mg/l^{-1}) for 24h at 22°C. Deionized water used as a control at the same condition.

Second part: In this experiment cut carnation flowers firstly treated with different concentrations of silver thiosulfate (0.25, 0.5 and 1 mM) for 2 h and then subjected to various concentrations of ethylene (1, 10 and 100 $\mu l/l^{-1}$) for 24 hours.

Postharvest experiments were carried out under vase life evaluation room conditions of 22±2°C, 60-70% relative humidity (RH) and 12 h photoperiod with cool white fluorescent lamps. The harvested flowers were put into vases containing distilled water and 10 mg l^{-1} chlorine.

Postharvest assessments

Longevity was recorded as days after treatment. The vase lives of flowers were considered when the edge of petals started to brown and lost their marketable quality. Relative fresh mass for stems was calculated using the formula: %fresh mass = $(W_t/W_{t=0}) \times 100$; where W_t = weight of stems (g) at Day 0, 2, 4, 6, etc. and $W_{t=0}$ = weight of the same stem (g) at day 0. Vase solution usage was determined using the formula: Solution uptake (ml $day^{-1}g^{-1}$, fresh weight) = $(S_{t-1}-S_t)/W_{t=0}$; where, S_t = solution weight (g) at t = Day 1, 2, 3, etc. S_{t-1} = solution weight (g) on the previous day and $W_{t=0}$ = fresh weight of the stem (g) at Day 0.
Some abbreviations which were used in this paper entitled such as STS=silver thiosulfate, NS=Nano-silver, B=extract of *Crambe orientalis* L., E=ethylene, SA= Salicylic acid, HA= Humic acid and SC= S-carvone.

Statistical analyses

Experiment was conducted in completely randomized design with 5 replications. Data were analyzed with SAS Release 9.1 for Windows. Duncan's Multiple Range Test (DMRT; P = 0.05) was used for comparison of treatment means.

Results

First experiment

The results of first experiment showed that the ethylene treatment significantly (P<0.05) reduced vase life of flowers compared to control. On the other words, flowers treated with ethylene lasted four times less than control. However, no significant differences were found among various concentrations of ethylene (Fig. 1).

According to the results of second part of first experiment, it is obvious that STS significantly (P<0.05) increased the vase life of cut carnation flowers compared to control and other treatments. There was a two-fold increase in vase life of flowers subjected to 0.25, 0.5, 1 and 1.5 mM of STS (20, 27, 25 and 21 days after initial treatment) in comparison with other treatments and control. Other treatments including different concentrations of S-carvon, Humic acid, N- silver, Salicylic acid and extract of *Brasica spp* did not significantly (P<0.05) influence flower postharvest life (Fig 2).

Second experiment (Part 1):

The results of these experiments revealed that different treatment significantly (P<0.05) affected vase life, fresh weight and solution uptake.

Vase life

Results in the first part of second experiment revealed that ethylene could promote the process of senescence and consequently reduced vase life of cut flowers. STS pre-treatment gave a significant extension of flower vase life at least 7.6 days compared to control. However, the STS pre-treatment at highest concentration (1 mM) provided 24.6 days of vase life when flowers were challenged with 1 $\mu l l^{-1}$ ethylene, but vase life of untreated flowers (control) was

10 days. The undesirable effects of ethylene were alleviated by application of all four concentrations of STS. It is obviously indicates that STS can block ethylene action regardless of its initial concentration. Also, results showed that higher concentrations of STS (0.5 and 1mM) were more effective than lower concentration (0.25 mM) in extending the longevity of flowers (Fig 3).

Relative fresh weight

It can be clearly seen that relative fresh weight (FW) of cut flower in all treatments increased gradually after the days 7 of the experiment. In contrast, there was a sharp fall in fresh weight of control flowers after 7 days and the downward trend continued to a low of 58% of initial fresh weight at the end of experiment. Despite flowers had been subjected to ethylene, flowers pretreated with different concentrations of STS followed by different concentrations of ethylene maintained FW until the last day (Fig. 4). Plants subjected to 10 and 100 µl/l ethylene showed similar results (Fig 5).

Solution uptake

According to data from Fig 6, it is clearly obvious that, all concentrations of STS alleviated the negative effects of high ethylene rates. However, the rate of solution uptake in STS treated flowers were significantly (P<0.05) higher than control in last day.
Flowers subjected to 0.25 and 0.5 mM of STS continued solution uptake until the last day of experiment and showed higher rate compared to control and other treatments. Moreover, the lower concentration of STS was more efficient than higher ones even in flower subjected with 10 and 100 $\mu l/l^{-1}$ of ethylene (Fig 6).

Second experiment (Part 2):

Vase life

According to the Fig 7, only STS could significantly (P≥0.05) increased vase life of cut carnation flower. Also, Nano-silver (NS) at rates of 20 and 50 mM and S-carvon at 1.2 slightly showed positive effects on flower vase life. There was a dramatic increase in flowers vase life in STS-treated flowers except the highest concentration (2 mM). On the other hands, lower concentrations of STS (0.25 and 0.5 mM) increased flower vase life more efficient than higher concentrations (1.5 and 2 mM). Hence, STS at rates of 0.25 and 0.5 mM increased the vase life of flowers by 15 days, while it did not noticeable at rates 1.5 and 2 mM. Humic acid, S-carvon (except at rate 1.2 mM) and *Brasica Spp* extract din not positively influence longevity of cut carnation flowers. However, Salicylic acid at rate 1.5 mM significantly (P≥0.05) decreased flower vase life compared to control (Fig. 7).

Relative fresh weight

The results of experiment revealed that, lower concentration (10 ppm) of humic acid positively influenced flower fresh weight throughout experiment and had more FW than control. Higher concentration of S-carvone (1.2 mM) was the most efficient treatment and increased fresh weight of cut carnation flowers (Fig. 8).

Crambe orientalis L. extract (B) at rates of 100, 500 and 750 ppm, maintained RFW of cut carnation flowers. Whereas, at lower concentrations (10 and 50 ppm) did not influence RFW (Fig. 9). It's concluded that the highest concentrations of NS (100 ppm) and SA (2 mM) had negative effects on RFW of flowers (Fig. 10). In contrast, lower concentrations of NS and SA showed slightly positive impact on RFW of cut carnation flower compared to control.
It is clearly obvious that STS at all concentrations had positive effects on RFW, and flowers treated with 0.25, 0.5, 0.75 and 1 mM of STS maintained their initial FW until the last day of experiment (Fig. 11).

Discussion

Results in this experiments showed that STS plays a key role in the maintenance of the vase life of cut carnation flowers. The STS mechanism in extending the vase life of cut flowers is related to suppression in the induction of autocatalytic production of ethylene, known as primary cause of early senescence of carnation flowers (Ichimura and Hiraya, 1999; Mor et al., 1984; Sexton et al., 1995)**.**
STS pre-treatment had greater efficacy against ethylene treatment. Reid *et al.* (1989) reported that the effect of exogenous ethylene (0.5 µl l^{-1}) on rose flowers could be overcome by pre-treatment with STS at a rate of 0.5 µmol $stem^{-1}$. Elgar *et al.* (2003) reported that exposure of *Leucocoryn ecoquimbensis* inflorescences to 8 µl l^{-1} ethylene for 24 h reduced its vase life from 10 to 5 days and pre-treatment with 1mM STS for 2 h protected flowers, giving a vase life of 9.1 days. Similarly, Macnish *et al.* (2000) reported that STS treatment was effective in providing waxflower with long termprotection against ethylene. Newman *et al.* (1998) reported that STS treatment was effective in affording long-term protection of developing buds on cut *Gypsophila paniculata* inflorescences against ethylene. They proposed that the STS complex remained available in the inflorescence and capable of binding to receptors formed as the buds opened into flowers. Delay in fresh weight loss by STS pretreatment in ethylene-treated flowers has also been reported for *Verticordia nitens* (Joyce and Poole, 1993).

The positive effect of NS on vase life and water uptake can be attributed to anti-bacterial effect of this compound. Furno et al. (2004) showed that because of their high surface area to volume ratio, nanometer sized silver (Ag^{+}) particles (NS) are considered to more strongly inhibit bacteria and other microorganisms than Ag in various oxidation states; Ag^{0}, Ag^{+}, Ag^{2+}, Ag^{3+}. Also Van Meeteren et al. (2001) reported that AgNO3 added to deionised water had a positive effect on *Bouvardia* water status and that use of tap water (containing a mixture of ions) had a similar effect to AgNO3 solution. Ions in water, particularly Cations, can enhance flow through xylem vessels (Van Ieperen *et al*., 2000).
Vase life of cut carnation flower was shortened at 100 ppm of NS. High concentrations of NS may be toxic to cut carnation. The negative effects of higher concentration of NS have been reported in gerbera cut flowers (Liu *et al*., 2009).
In this experiment the higher levels of *Crambe orientalis* L. extract positively influenced the RFW of flowers. The effect of some plant extracts on extending the longevity of cut flowers has been reported previously. For instant, rosemary's extract increased vase life of cut carnation flowers. This increase on vase life of cut flowers, petals and leaves of cut carnation is caused mainly by decreasing of bacteria concentration in vase solutions.
Salicylic acid did not influence the vase life of cut carnation flowers. This result was in agreement with those of Capdeville *et al*. (2003) who reported that this compound could not increase the longevity of rose flowers.

Overall, sensitivity to ethylene is key issues in the postharvest longevity of cut “White Sim” carnation flowers. The STS mechanism in extending the vase life of cut flowers is related to suppression in the induction of autocatalytic production of ethylene. This difference may be attributable to a residual ‘pool’ of STS in pre-treated flowers that yields silver ions to block newly forming ethylene binding sites. The positive effect of NS on vase life and water uptake can be attributed to its anti-bacterial effect. The higher levels of *Crambe orientalis* L. extract positively influenced the RFW of flowers. This increase on vase life of cut flowers, petals and leaves of cut carnation is possibly caused by decreasing of bacteria concentration in vase solutions. Salicylic acid and Humic acid did not influence the vase life of cut carnation flowers. It seems these compound could not influence ethylene production and may be did not affect the RFW and Solution uptake of cut “White Sim” carnation flowers.

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Figures:

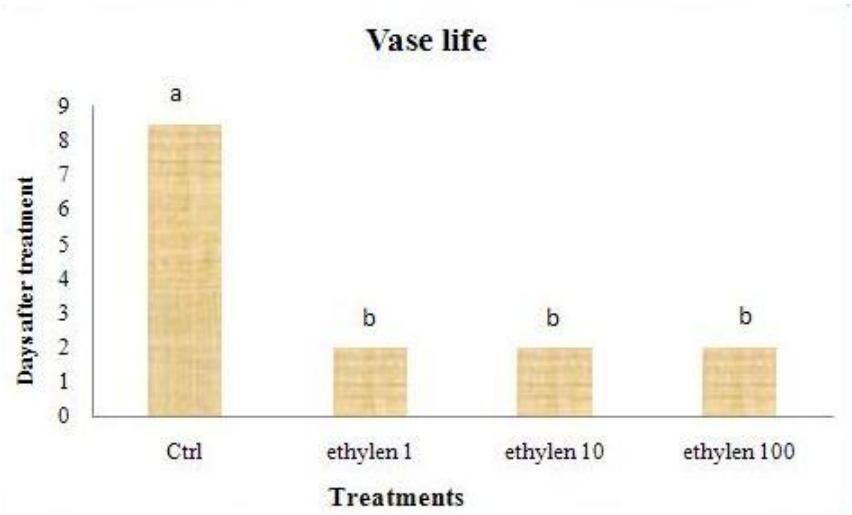

Fig.1. The effects of different concentrations of ethylene (μll^{-1}) on vase life of flowers.

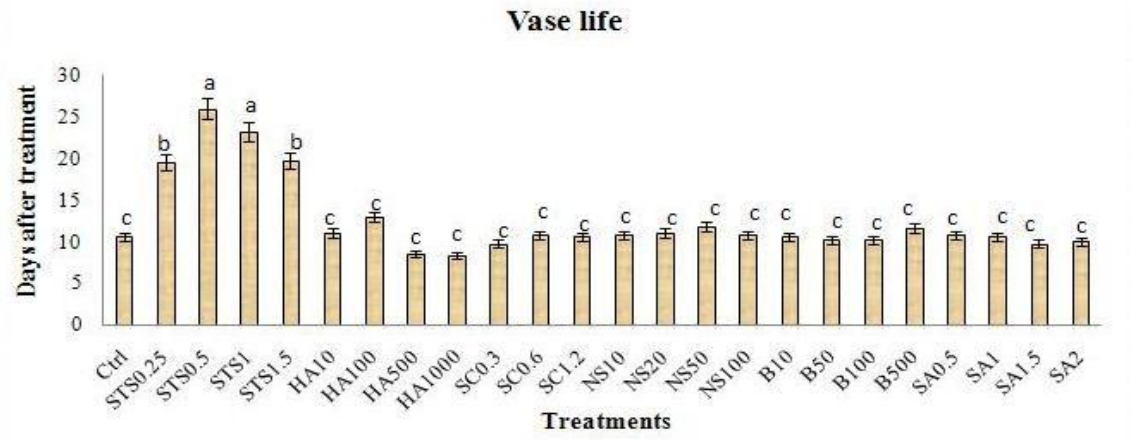

Fig. 2. The effects of different treatments on vase life of cut carnation flowers.

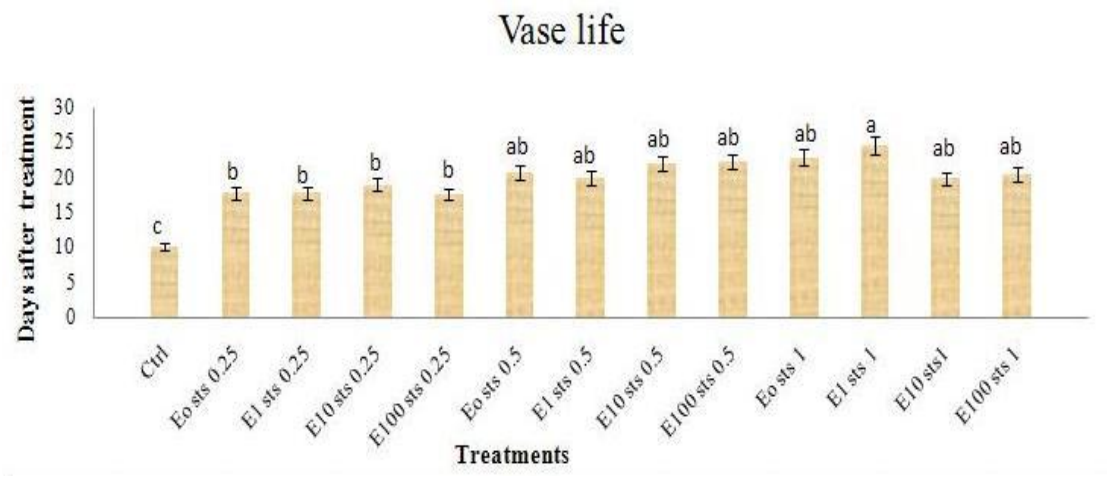

Fig.3. The effects of different rates of ethylene and STS on vase life of cut carnation flowers.

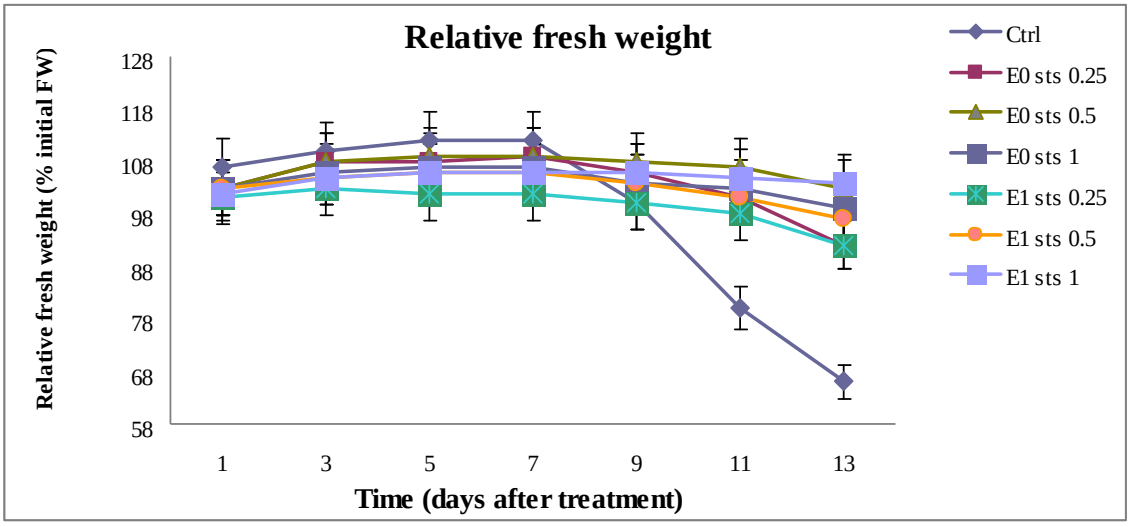

Fig.4. Effects of ethylene (0 and 1 µl/l^{-1}) and STS pretreatments (0.25, 0.5 and 1 mM) on relative fresh weight of cut carnation flowers.

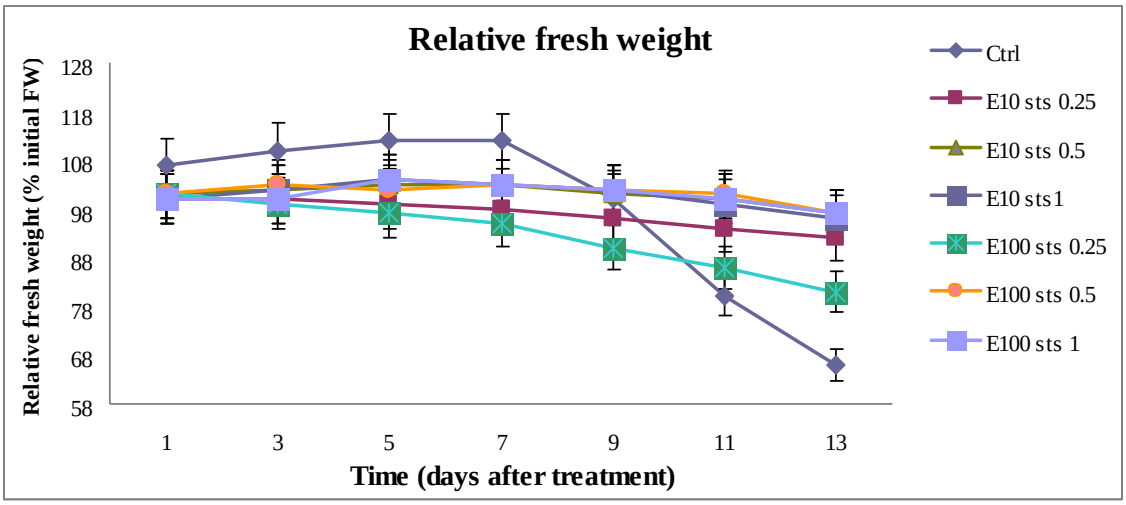

Fig. 5. The effects of ethylene (10 and 100 µl/l^{-1}) and STS pretreatments (0.25, 0.5 and 1 mM) on relative fresh weight of cut carnation flowers.

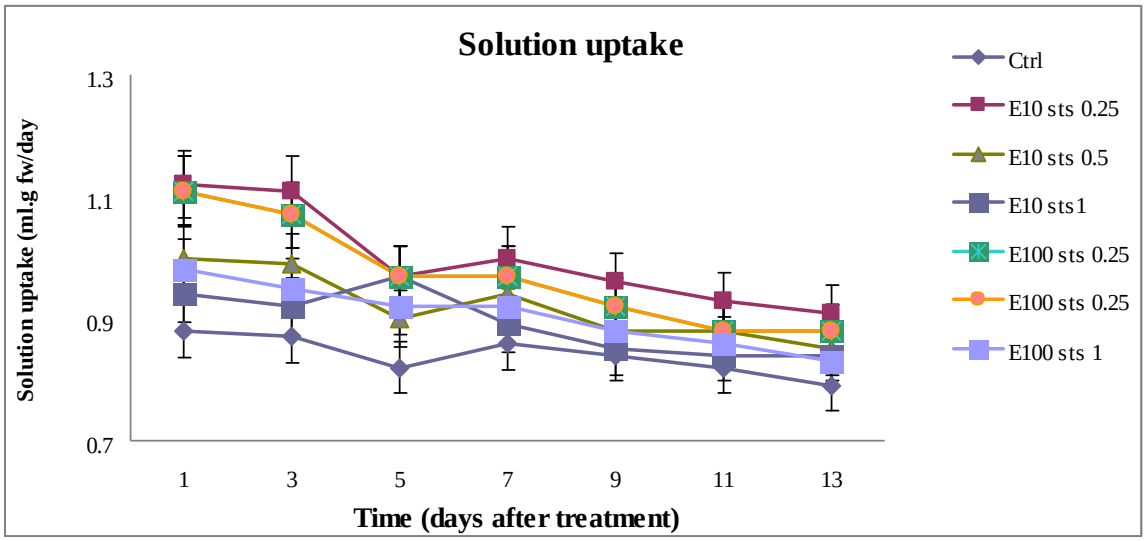

Fig. 6. The effects of ethylene (10 and 100 µl/l^{-1}) and STS pretreatments (0.25, 0.5 and 1 mM) on solution uptake of cut carnation flowers.

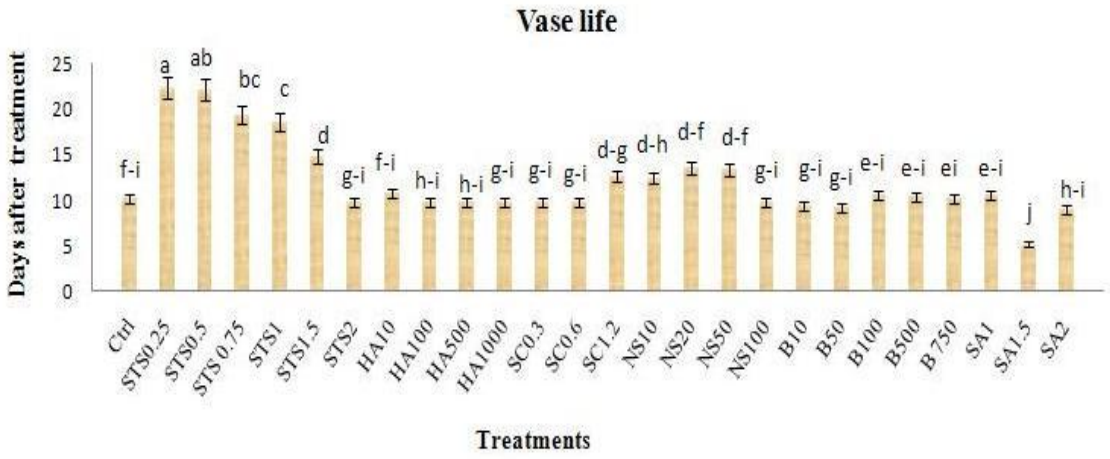

Fig.7. The effects of various treatments on vase life of cut carnation flowers.

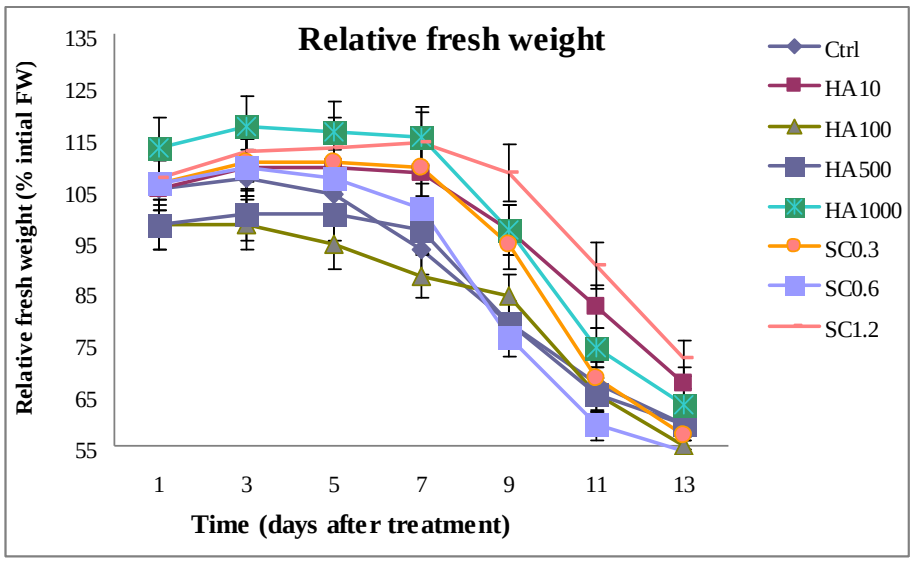

Fig.8. The effects of various concentrations of S-carvone and Humic acid on RFW of flowers.

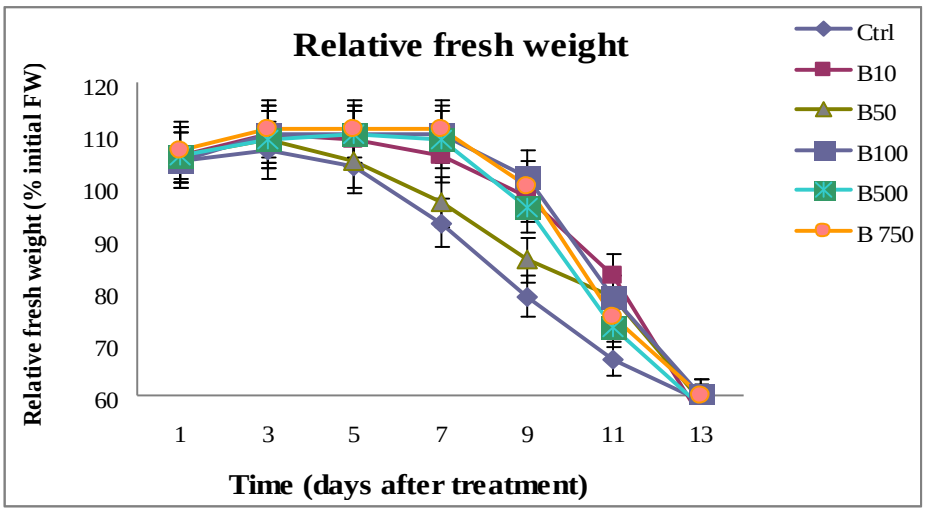

Fig.9. The effects of different concentrations of *Crambe orientalis* L. extract on RFW of flowers.

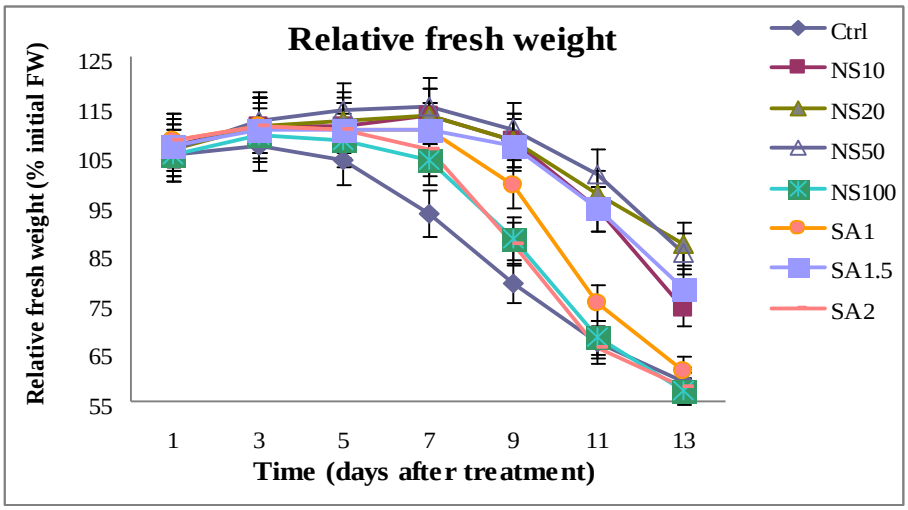

Fig.10. The effects of various concentrations of Nano-Silver and Salicylic acid on RFW of flowers.

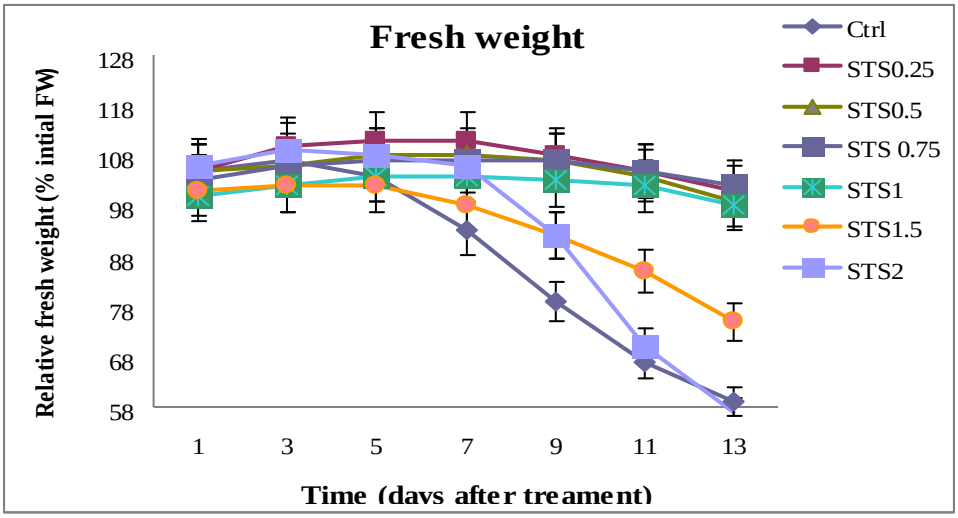

Fig.11. The effects of different concentrations of STS on RFW of flowers.