

# Extending vase life of *Narcissus tazetta* L. cut flowers using selenium and 1-methylcyclopropene treatments

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## Abstract

The effects of 1-methylcyclopropene (1-MCP) and selenium (Se) on postharvest quality and the vase life of *Narcissus tazetta* were investigated. A factorial experiment based on a completely randomized design with 1-MCP at concentrations of 0, 0.5, and 1  $\mu\text{L L}^{-1}$  and Se at 0, 1 and 2  $\text{mg L}^{-1}$  with 3 replicates (4 cut flowers per each replicate) was conducted. The results showed that treatment of cut flowers with 1-MCP and Se significantly increased the vase life, water uptake and relative fresh weight of *N. tazetta* cut flowers. Fresh weight of flower increased from 0.58 (control) to 0.92 g using 1  $\mu\text{L L}^{-1}$  1-MCP treatment. Total soluble solids (TSS) and total soluble sugar of flowers treated with all the levels of 1-MCP and Se significantly decreased as compared to control. Total phenolic content and antioxidant activity of treated cut flowers with 1-MCP and Se were significantly increased in comparison to the control. The highest (13.41 days) vase life was obtained in 1  $\mu\text{L L}^{-1}$  1-MCP treatment. The study revealed that application of 1-MCP and Se delayed senescence symptoms resulting extended vase life and postharvest quality of *N. tazetta* cut flowers.

**Key words:** Flower senescence, *Narcissus tazetta*, postharvest life, relative fresh weight, total soluble sugar, water uptake

## Introduction

*Narcissus tazetta* is a bulbous perennial plant in the family Amaryllidaceae, which is used as cut, pot or landscape flower. The flowering time of *N. tazetta* is from mid-autumn to mid-winter. *N. tazetta* is the most extensive species of the genus *Narcissus* spreading from Spain, Iran, Kashmir to China and Japan (Dole and Wilkins, 2005). They have a strong fragrance that is highly valued in the perfume industry (van Dort *et al.*, 1993; Chen *et al.*, 2013). However, the short vase life of *N. tazetta* cut flowers and the rapid wilting of its petals are among the limiting factors in the maintenance and sale of this flower after harvest (Bayat and Aminifard, 2018).

Postharvest senescence is a major limitation to the marketing of many cut flowers and it is necessary to develop desirable postharvest treatments to prolong their vase life and marketing period (Bayat *et al.*, 2011, Bayat and Aminifard, 2018). Application of preserving substances is a widely used method to extend the vase life of cut flowers (Bayat and Aminifard, 2017; Vahdati Mashhadian *et al.*, 2012). In cut flowers, where ethylene has been implicated in the control of floral senescence the use of ethylene inhibitors usually prolongs the vase life (Serek and Sisler, 2001). It has been demonstrated that narcissus flowers are sensitive to ethylene (Hunter *et al.*, 2004). Hence, in order to extend the vase life of *N. tazetta* cut flower, it is necessary to control ethylene production and perception.

1-Methylcyclopropane (1-MCP) has been identified as a preservative agent that prevents the action of ethylene through competitive inhibition. It is irreversibly attached to ethylene receptors and thus can increase the vase life of many cut flowers (Serek and Sisler, 2001). 1-MCP has been found to

delay senescence in *Lilium* (Celikel *et al.*, 2002), in *freesia* (Zencirkiran, 2010) and in *Dendrobium* (Almasi *et al.*, 2019).

Higher plants are thought not to require Se, but several studies demonstrate that Se at low concentrations improves physiological and biochemical processes in plants (Saffaryazdi *et al.*, 2012; Nawaz *et al.*, 2016). Postharvest treatment of Se has been reported to postpone senescence by improving antioxidant activity and reducing ethylene production (Malorgio *et al.*, 2009; Feng *et al.*, 2013).

Literature reviews show that 1-MCP treatment at 1  $\mu\text{L L}^{-1}$  was effective in extending the vase life of florets of *N. tazetta* (Komada *et al.*, 2013). However, no information is available regarding the effect of Se and the combination treatment of Se and 1-MCP on the postharvest performance and vase life of *N. tazetta* cut flower. Therefore, the aim of this study was to evaluate the effects of Se and 1-MCP treatments and their combination on the vase life, water uptake, and antioxidant activity of *N. tazetta* cut flowers.

## Materials and methods

**Experimental material:** Cut *N. tazetta* L. cv. Shahla were obtained from a local farm in Khusf city (32° 48' 11" N and 58° 54' 14" E), South Khorasan Province, Iran, on December 2018. Plants were grown under natural conditions. The cut flowers were picked up in the early morning (when the first flower opened) and immediately moved to the laboratory in proper packages. Stems were trimmed to 40 cm and placed in the glass vials containing 400 mL of the test solutions. The experiment was carried out at 23±1°C and 70 % relative humidity under 10  $\mu\text{mol m}^{-2} \text{s}^{-1}$  fluorescent light with 12/12 hours of light/darkness regime (Ichimura and Goto, 2002).

**Postharvest treatments:** *N. tazetta* cut flowers were divided into two lots. The first lot was placed in 15 L plastic containers, sealed and exposed to 1-MCP at concentration of 0, 0.5 and 1  $\mu\text{L L}^{-1}$  for 24 h at 22 °C, while the second lot remained untreated. 1-MCP was prepared, applied and measured as described in Moradinezhad *et al.* (2008). Thereafter, all the cut flowers (1-MCP treated and untreated) were placed in vase solutions containing Se at concentration of 0, 1 and 2  $\text{mg L}^{-1}$ . The source of Se was  $\text{Na}_2\text{O}_4\text{Se}$  (Sigma-Aldrich Co, Germany). Distilled water was used as control.

The vase life of spike was determined as the time from harvest to wilting of the last floret (Ichimura and Goto, 2002). Fresh weight of cut flower was measured every day until day 8. To measure relative fresh weight, the following formula was used (Sairam *et al.*, 2002):

$$\text{R.F.W. (\%)} = (W_t/W_0) \times 100$$

Where,  $W_t$  represents the fresh weight in the first eight days of experiment and  $W_0$  denotes the initial fresh weight at the beginning of the experiment.

The opening of each vase was covered in order to limit evaporation loss of vase solution and to allow determination of the solution uptake by cut flowers (Sairam *et al.*, 2002). Total soluble sugar was determined according to Irigoyen *et al.* (1992) method. The total soluble solids (TSS) in the petal extract was measured by a refractometer (RF 10, 0-32 %, Exttech Co., USA) and the results were expressed as °Brix. Total phenolic content and antioxidant activity were determined according to the methods of Singleton and Rossi (1965) and Koleva *et al.* (2002), respectively. The antioxidant activity was calculated using the following equation:

$$\text{Antioxidant activity (\% inhibition)} = 1 - A_{\text{Sample}(515 \text{ nm})} / A_{\text{Control}(515 \text{ nm})} \times 100.$$

At the end of the experiment, dry and fresh weights of flowers (without stem) were measured. For this purpose, flowers from all replications and each sample were weighed as fresh weight and then, they were dried at 70 °C for 48 h to estimate the dry weight (Sairam *et al.*, 2002).

**Experimental design and data analysis:** The experiment was carried out using a completely randomized design. Each treatment comprised three replicates and four samples (individual flowers) for each replication. Collected data were subjected to analysis of variance (ANOVA) and the mean values was assessed by LSD Test at  $P \leq 0.05$  using the JMP 8 program (SAS Campus, Cary, NC, USA).

## Results

The results of the analysis of variance showed significant effects of Se, 1-MCP and Se  $\times$  1-MCP on all measured traits of *N. tazetta* cut flowers (Tables 1 and 2).

**Total water uptake:** The highest total water uptake was obtained from 1.0  $\mu\text{L L}^{-1}$  1-MCP treatment during the first eight days of the experiment, which indicates a 31 % increase compared to the control (Table 3). Moreover, daily water uptake of cut flowers was illustrated until day 8 of the experiment. On every day of the experiment, the highest water uptake was recorded in cut flowers treated with 1  $\mu\text{L L}^{-1}$  1-MCP (Fig. 1).

**Relative fresh weight:** According to the results depicted in Fig. 2, there were significant differences in relative fresh weight of treated cut flowers during days 1 to 8. Relative fresh weight of

Table 1. Analysis of variance (ANOVA) of the effect of Se and 1-MCP on total water uptake and flower fresh and dry weight of *N. tazetta* cv. Shahla cut flowers

Source of variation	df	MS		
		Total water uptake	Flower fresh weight (without stem)	Flower dry weight (without stem)
Se	2	13.23**	0.065**	0.0021**
MCP	2	24.49**	0.058**	0.0009**
Se $\times$ MCP	4	3.08**	0.035**	0.0006**
Error	16	0.54	0.003	0.0001

\* and \*\* significant at 5 and 1 % probability levels, respectively.

Table 2. Analysis of variance (ANOVA) of the effect of Se and 1-MCP on the TSS, total soluble sugar, total phenolic content, antioxidant activity and vase life of *N. tazetta* cv. Shahla cut flower

Source of variation	df	MS				
		TSS	Total soluble sugar	Total phenolic content	Antioxidant activity	Vase life
Se	2	7.91**	91.84**	10.76**	1214.18**	0.44*
MCP	2	4.33**	207.15**	1.80**	348.55**	8.00**
Se $\times$ MCP	4	2.13*	174.57**	4.08**	462.32**	0.56**
Error	16	0.60	12.08	0.26	15.24	0.12

\* and \*\* significant at 5 and 1 % probability levels, respectively.

1-MCP (1  $\mu\text{L L}^{-1}$ ) treatment was higher than other treatments from day 3 to 8 of the experiment. On day 8, the relative fresh weight of 1-MCP treated cut flowers at 1  $\mu\text{L L}^{-1}$  was 33 % greater than the control.

**Fresh and dry weight of flower:** According to the results in Table 3, treatment of *N. tazetta* cut flowers by Se and 1-MCP significantly improved the fresh and dry weight of flowers (without stem) as compared to the control. Fresh weight of the control flower was increased from 0.58 to 0.92 g in 1-MCP treated cut flowers at 1.0  $\mu\text{L L}^{-1}$ . The highest dry weight of flower (0.170 g) was recorded in 0.5  $\mu\text{L L}^{-1}$  1-MCP treatment, which indicates an increase of 33 % compared to the control.

Table 3. Interaction effect of Se and 1-MCP on total water uptake, flower fresh and dry weight (without stem) of *N. tazetta* cv. Shahla cut flower

Se ( $\text{mg L}^{-1}$ )	1-MCP ( $\mu\text{L l}^{-1}$ )	Total water uptake ( $\text{g stem}^{-1}$ )	Flower fresh weight (g)	Flower dry weight (g)
0	0	14.01 de <sup>1</sup>	0.58 cd	0.127 b
	0.5	17.36 ab	0.89 a	0.170 a
	1.0	18.40 a	0.92 a	0.167 a
1	0	12.95 e	0.62 cd	0.125 b
	0.5	13.75 e	0.56 d	0.119 b
	1.0	16.30 bc	0.77 b	0.156 a
2	0	13.16 e	0.63 cd	0.122 b
	0.5	15.84 c	0.67 bc	0.120 b
	1.0	15.03 cd	0.65 cd	0.123 b

<sup>1</sup> Means followed with the same letter (s) are not significantly different at 5 % probability level using the LSD test.

**TSS and total soluble sugar:** TSS and total soluble sugar of cut flowers treated with Se and 1-MCP treatments significantly decreased in comparison to the control. The highest (124.35  $\text{mg g}^{-1}$  DW) and the lowest (97.53  $\text{mg g}^{-1}$  DW<sup>-1</sup>) total soluble sugars were obtained from the control and 1  $\mu\text{L L}^{-1}$  1-MCP treated cut flowers, respectively (Table 4).

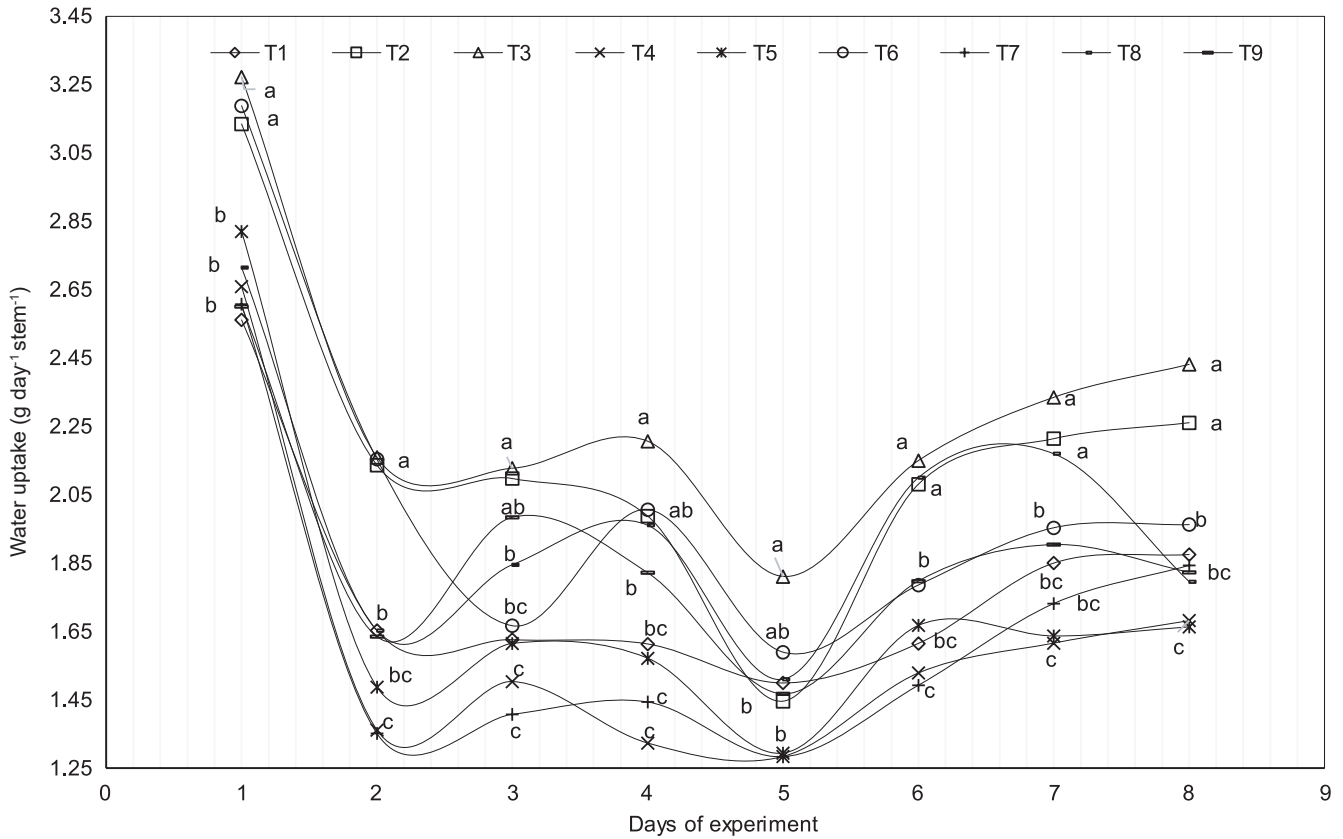


Fig. 1. Interaction effect of Se and 1-MCP on daily water uptake of *N. tazetta* cv. Shahlia cut flower during the eight first days of the experiment. T1: Control; T2: 0.5  $\mu\text{L L}^{-1}$  1-MCP; T3: 1  $\mu\text{L L}^{-1}$  1-MCP; T4: 1  $\text{mg L}^{-1}$  Se; T5: 1  $\text{mg L}^{-1}$  Se + 0.5  $\mu\text{L L}^{-1}$  1-MCP; T6: 1  $\text{mg L}^{-1}$  Se + 1  $\mu\text{L L}^{-1}$  1-MCP; T7: 2  $\text{mg L}^{-1}$  Se; T8: 2  $\text{mg L}^{-1}$  Se + 0.5  $\mu\text{L L}^{-1}$  1-MCP; T9: 2  $\text{mg L}^{-1}$  Se + 1  $\mu\text{L L}^{-1}$  1-MCP

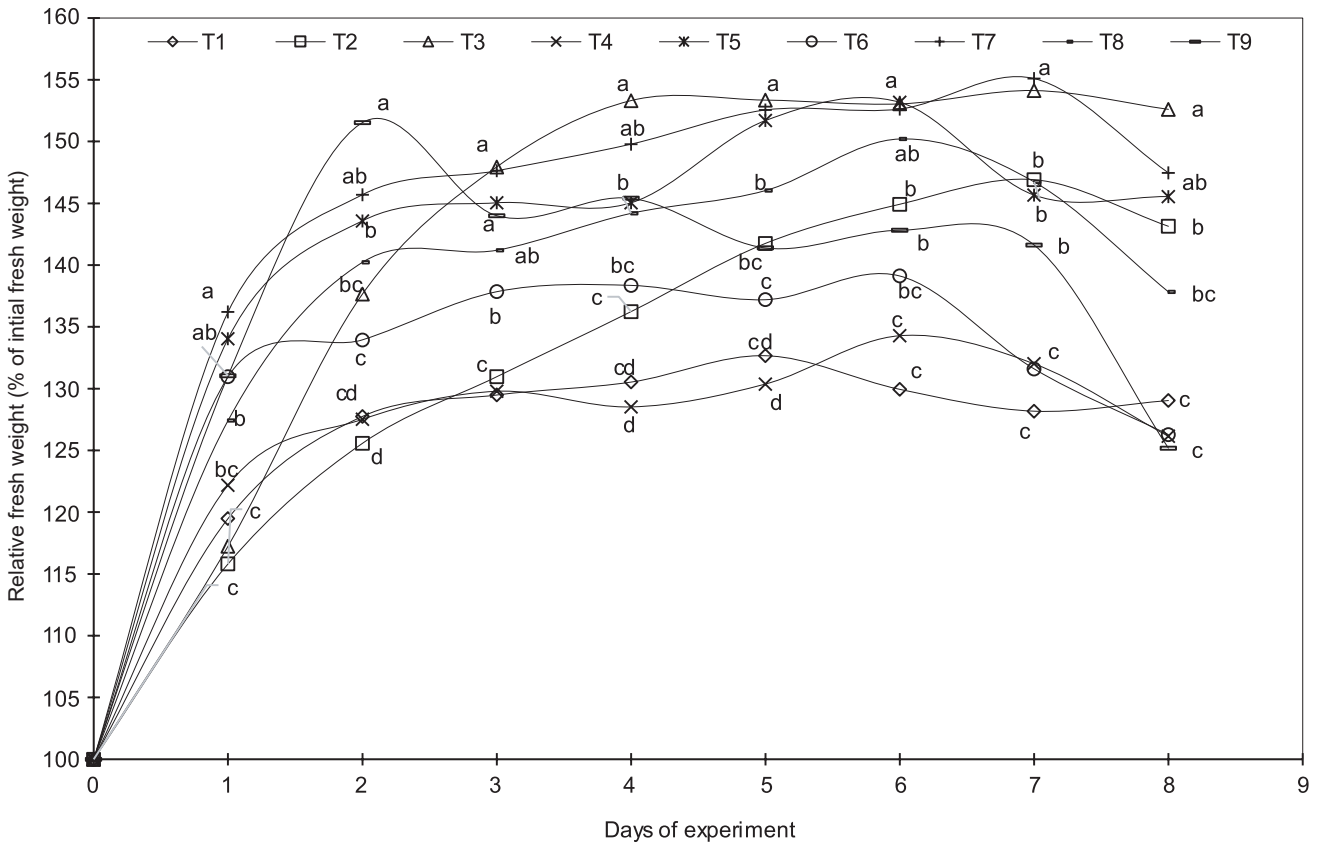


Fig. 2. Interaction effect of Se and 1-MCP on relative fresh weight *N. tazetta* cv. Shahlia cut flower during the eight first days of the experiment. T1: Control; T2: 0.5  $\mu\text{L L}^{-1}$  1-MCP; T3: 1  $\mu\text{L L}^{-1}$  1-MCP; T4: 1  $\text{mg L}^{-1}$  Se; T5: 1  $\text{mg L}^{-1}$  Se + 0.5  $\mu\text{L L}^{-1}$  1-MCP; T6: 1  $\text{mg L}^{-1}$  Se + 1  $\mu\text{L L}^{-1}$  1-MCP; T7: 2  $\text{mg L}^{-1}$  Se; T8: 2  $\text{mg L}^{-1}$  Se + 0.5  $\mu\text{L L}^{-1}$  1-MCP; T9: 2  $\text{mg L}^{-1}$  Se + 1  $\mu\text{L L}^{-1}$  1-MCP

**Total phenolic content and antioxidant activity:** The results showed that total phenolic content and antioxidant activity of cut flowers treated with all the levels of 1-MCP and Se significantly increased in comparison to the control. The highest total phenolic content and antioxidant activity were obtained in combination treatment of 2 mg L<sup>-1</sup> Se + 0.5 µL L<sup>-1</sup> 1-MCP (Table 4).

Table 4. Interaction effect of Se and 1-MCP on the TSS, total soluble sugar, total phenolic content and antioxidant activity of *N. tazetta* cv. Shahla cut flowers.

Se (mg L <sup>-1</sup> )	1-MCP (µL L <sup>-1</sup> )	TSS (°Brix)	Total soluble sugar (mg g <sup>-1</sup> DW <sup>-1</sup> )	Total phenolic content (mg g <sup>-1</sup> FW <sup>-1</sup> )	Antioxidant activity (%)
0	0	20.33 a <sup>1</sup>	124.35 a	3.86 c	39.40 d
	0.5	20.02 ab	102.44 cde	3.93 c	39.48 d
	1.0	18.33 cd	97.53 e	5.98 b	64.02 bc
1	0	18.60 bc	99.11 de	4.42 c	45.30 d
	0.5	17.00 de	103.79 cd	6.82 ab	69.96 ab
	1.0	17.66 cde	103.05 cde	6.11 b	65.62 bc
2	0	18.00 cde	111.18 b	7.09 a	72.76 a
	0.5	19.01 abc	108.30 bc	7.16 a	76.47 a
	1.0	16.75 e	103.52 cde	5.86 b	63.06 c

<sup>1</sup> Means followed with the same letter (s) are not significantly different at 5 % probability level using the LSD test.

**Vase life:** The results showed that all treatments significantly

increased the vase life of *N. tazetta* cut flowers as compared to the control (except 2 mg L<sup>-1</sup> Se). The highest (13.41 days) vase live was observed in 1-MCP treated cut flowers at 1.0 µL L<sup>-1</sup> (Fig. 3).

### Discussion

After cutting, the fresh weight of cut flowers decreases due to the loss of water uptake and increasing water loss through transpiration (Borochoy *et al.*, 1995; Liao *et al.*, 2012; Mansouri, 2012). The present results showed that Se and 1-MCP treatments significantly increased water uptake, relative fresh weight, and fresh weight of flowers as compared to the control. The positive effect of 1-MCP treatments on the fresh weight have also been reported in rose (Chamani *et al.*, 2005), in patumma (*Curcuma alismatifolia*) (Chutichude *et al.*, 2011) and in *Dendrobium* (Almasi *et al.*, 2019) cut flowers. The increase in flower fresh weight with 1-MCP treatment could probably be due to blockage of ethylene receptors which reduced ethylene sensitivity. This blockage postpones the climacteric rise of respiration and ethylene production and thus, the freshness of flowers would be maintained longer (Almasi *et al.*, 2019). In addition, it is reported that Se increased the fresh weight of lettuce by lowering phenylalanine ammonia lyase activity and ethylene production (Malorgio *et al.*, 2009). Overall, the 1-MCP and Se treatments result in lower postharvest metabolism of *N. tazetta*, mainly by decreasing respiratory activity and ethylene production, and improving scavenging capacity and water relation of the cut flowers.

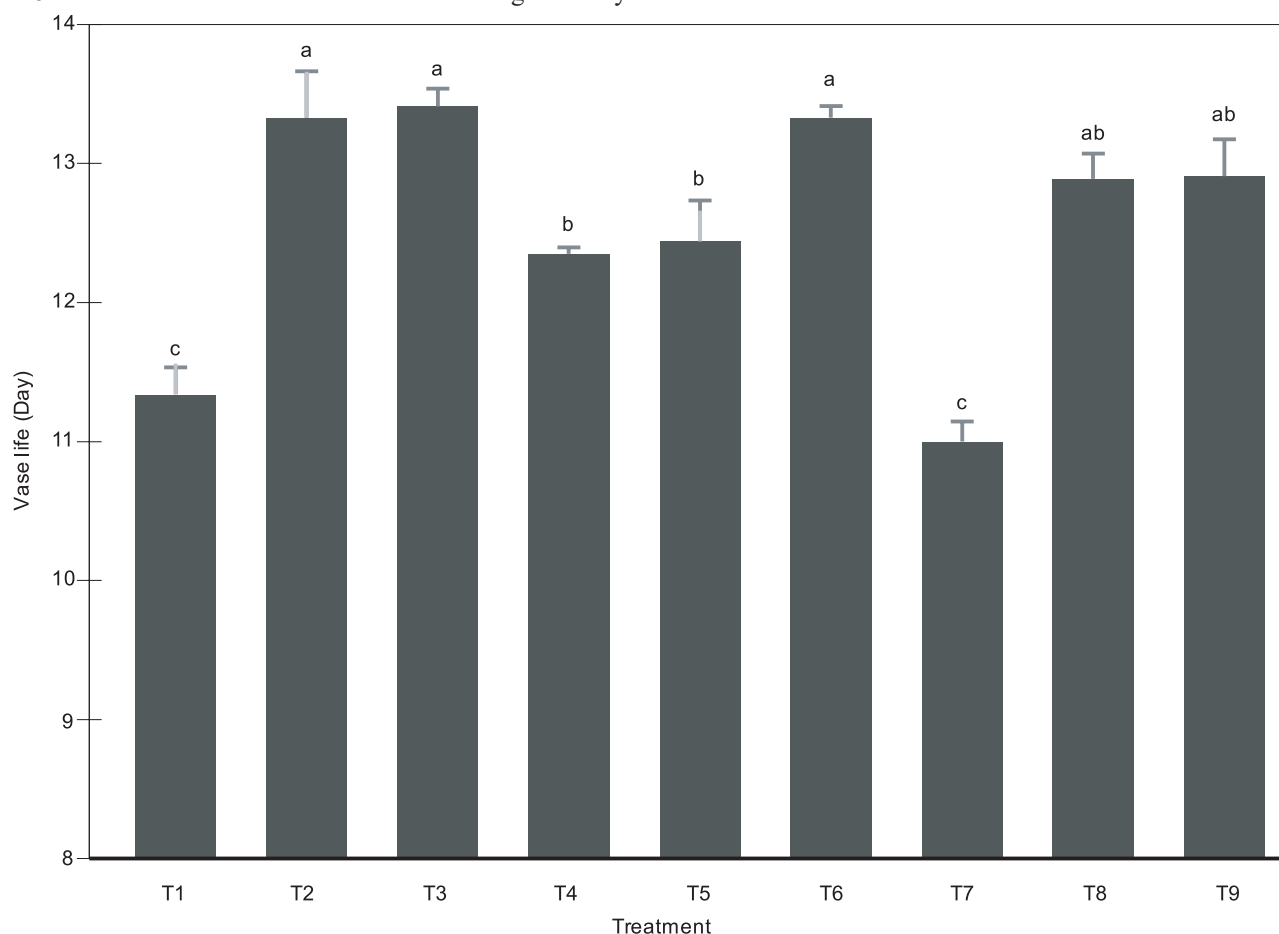


Fig. 3. Interaction effect of Se and 1-MCP on the vase life of *N. tazetta* cv. Shahla cut flowers. T1: Control; T2: 0.5 µL L<sup>-1</sup> 1-MCP; T3: 1 µL L<sup>-1</sup> 1-MCP; T4: 1 mg L<sup>-1</sup> Se; T5: 1 mg L<sup>-1</sup> Se + 0.5 µL L<sup>-1</sup> 1-MCP; T6: 1 mg L<sup>-1</sup> Se + 1 µL L<sup>-1</sup> 1-MCP; T7: 2 mg L<sup>-1</sup> Se; T8: 2 mg L<sup>-1</sup> Se + 0.5 µL L<sup>-1</sup> 1-MCP; T9: 2 mg L<sup>-1</sup> Se + 1 µL L<sup>-1</sup> 1-MCP.



In this study, the level of TSS and total soluble sugars in treated cut flowers with 1-MCP and Se was less than control. Similar results were reported by Huang *et al.* (2017) in rose cut flowers, which had a lower respiratory rate and small consumption of photoassimilates. Lower total soluble sugar observed in the present study is an indication of a delay in senescence of the treated flowers in comparison to untreated control flowers. These treatments improved the postharvest characteristics (less ethylene production and better flow of water) and delayed the senescence, so internal reservoir structures like starch would maintain for a longer period and this can be responsible for lower carbohydrates and higher dry weight of the treated flowers (Bayat and Aminifard, 2018).

In this study, the results showed that Se and 1-MCP treatments significantly improved total phenolic content and antioxidant activity of flowers compared to the control. Zhu *et al.* (2017) reported that Se extended the shelf life of tomato fruit by enhancing the antioxidant defense system. In the senescing flowers, the levels of reactive oxygen species (ROS) increase that can damage proteins, lipids, carbohydrates, and nucleic acids (Gill and Tuteja, 2010). Selenium diminished ROS production and protected membrane integrity during senescence (Feng *et al.*, 2013). Therefore, Se extends the vase life of *N. tazetta* flowers by controlling ROS level and oxidative damage. As well, a considerable increase in antioxidant enzymes activity was observed in petals of carnation flower treated with 1-MCP (Karimi, 2014). 1-MCP protected antioxidant enzymes by inhibition of ethylene action and biosynthesis and finally prevention of respiration (Ranjbar and Ahmadi, 2015).

The application of 1-MCP and Se significantly extended the vase life of narcissus cut flowers compared to the control. Extending the vase life of different cut flowers by the application of 1-MCP has been reported in previous studies (Valenzuela-Vázquez *et al.*, 2007; Zencirkiran, 2010; Komada *et al.*, 2013; Almasi *et al.*, 2019). It has been reported that narcissus flower is sensitive to ethylene. Hence, ethylene accelerates the senescence of *N. tazetta* flowers and decreases their vase life (Hunter *et al.*, 2004). 1-MCP inactivates autocatalytic ethylene production by the binding to the ethylene receptors and thus, flowers will be protected from both endogenous and exogenous ethylene production (Serek and Sisler, 2001). Moreover, extending the shelf life of lettuce and tomato has been reported with Se treatment (Malorgio *et al.*, 2009; Zhu *et al.*, 2017). Zhu *et al.* (2017) reported that application of Se decreased ethylene production and respiration rate in tomato fruits. Selenium also reduced reactive oxygen species (ROS) production and protected membrane integrity during senescence (Djanaguiraman *et al.*, 2005). Thus, the ability of Se to prolong the vase life of *N. tazetta* cut flowers can be associated with control of oxidative damage and inhibition of ethylene production.

The results showed that application of 1-MCP and Se delayed senescence and significantly increased the vase life, water uptake, and relative fresh weight of *N. tazetta* cut flowers in comparison to the control. However, the beneficial effects of 1-MCP were greater than Se. Among all treatments, the better results were obtained from the application of 0.5 and 1  $\mu\text{L L}^{-1}$  1-MCP and therefore are recommendable for practical application.

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