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Full Length Research Paper

Quality management of cut carnation 'Tempo' with 1-MCP

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Water relation and chlorophyll content are two important factors on the postharvest quality of cut flowers. 1-MCP (1–methylcyclopropene), as a gaseous inhibitor of ethylene action, significantly delayed the wilting of cut carnation (*Dianthus caryophyllus* L.). The effects of 1-MCP depends on concentration, time duration and temperature. In this study, the effect of different 1-MCP concentrations (0, 20, 40, 60, 80 and 100 nl l^{-1}) and time durations (3, 6 and 9 h) on the vaselife, water uptake, loss of fresh weight and chlorophyll index of cut carnation 'Tempo' which is an ethylene-sensitive flower, were evaluated. The effects of 1-MCP concentrations and interaction between 1-MCP concentration and time duration on the vaselife, water uptake, loss of chlorophyll index and loss of fresh weight, were significant at 1% levels of probability. Also the effect of time duration on the loss of chlorophyll index and loss of fresh weight was significant at 5% and on the water uptake was significant at 1% of probability. Treatment with 60 nl l^{-1} 1-MCP for 3 h with 16.47 days vaselife, 2.57 ml g^{-1} fresh weight, 2.41 ml g^{-1} water uptake and 2.667 loss of chlorophyll index was better than other treatments.

Key words: *Dianthus caryophyllus* L., 1-methylcyclopropene, vaselife, water uptake, cut flower.

INTRODUCTION

The postharvest life of many cut flowers is lowered by exposure to ethylene (Reid and Wu, 1992). Cut carnation is very sensitive to ethylene (Wolthering and Van Doom, 1998). The inhibition of ethylene action by pretreatment with STS and DACP has become an important commercial technique for improving the life of ethylene-sensitive flowers (Serek et al., 1994; Serek and Sisler, 2001). STS and DACP are markedly effective in extending the vaselife of many cut flowers such as carnation, alstromeria, snapdragon and rose (Mayers et al., 1997; Serek et al., 1994a). However, STS contains silver ion that is a potent environmental pollutant and DACP is an unstable and potentially explosive chemical (Serek et al., 1995b). Therefore, it needs to be replaced by other non-toxic chemical compounds.

A volatile and simple organic compound, 1-MCP, as a potent inhibitor of ethylene action in cut flowers has a similar action with STS and DACP. 1-MCP appears to be non-toxic and is quite stable under normal conditions (Serek et al., 1994) and maintains specific quality attributes and improves the longivity of many fresh products (Blankenship and Dole, 2003). This chemical compound is more effective than ethylene in lower concentration and longer time durations (Blankenship and Dole, 2003; Blankenship, 2001).

The effect of 1-MCP, has been reported to prolong the postharvest life of flowers in potted plants including rose and begonia (Serek et al., 1994), kalanchoe (Nell et al., 2000; Kebenei et al., 2003), and *Hibiscus rosa-sinensis* L. (Reid et al., 2002). Similarly, the vaselife of various cut flowers such as carnation and snapdragon can be extended by 1-MCP fumigation (Serek et al., 1995b; Sisler et al., 1996), christmas cactus and bellflower (Serek and Sisler, 2001), *Pelargonium peltatum* (Cameron and Reid, 2001), *Delphinium* (Ichimura et al., 2002) and sweet pea (Kebenei et al., 2003).

1-MCP concentration, time duration and temperature are important factors for effectiveness of this compound

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Table 1. The effect of 1-MCP concentrations on different characteristics of cut carnation 'Tempo'.

Loss of fresh weight (g)	Loss of chlorophyll index	Water uptake (ml g^{-1} F.W.)	Vaselife (days)	1-MCP concentration (nl l^{-1})
3.681 a	11.02 a	2.01 b	12.38 c	0
2.944 b	9.63 b	2.18 ab	12.82 bc	20
2.106 cd	6.41 d	2.30 ab	14 b	40
1.924 d	3.76 e	2.41 a	15.49 a	60
2.533 bc	4.56 e	2.33 ab	14.18 b	80
2.545 bc	8.36 c	2.25 ab	13.36 bc	100

Mean values with the same letters are not significantly different at 0.01 by S.N.K.

(Blankenship and Dole, 2003; Blankenship, 2001; Nell et al., 2000; Sisler and Serek, 1997). Generally, high concentration of 1-MCP is needed in low temperatures, as in this condition, molecular binding to receptors happens frequency (Sisler and Serek, 1997). In most studies, temperature between 20 - 25°C (Blankenship, 2001; Nell et al., 2000) and 12 - 24 h time duration are sufficient for effectiveness of 1-MCP. There is a reverse relation between temperature and time duration. Obviously, in case of concentration and temperature increments, time duration can be reduced (Blankenship and Dole, 2003).

The objective of current study was to investigate the effect of different 1-MCP concentrations and time duration on the vaselife, water uptake, loss of chlorophyll index and loss of fresh weight in cut carnation 'Tempo' and finally determining the optimal concentration and time duration.

MATERIALS AND METHODS

Cut flowers were harvested in optimum developmental stage from researching greenhouse of National Research Center of Ornamental Plants in Mahallat, Iran, in the morning and transported with appropriate covers immediately. They were cut obiquely in 50 cm of length and then weighting and were put in vases containing 250 mg l^{-1} hydroxy quinoline citrate under air-tight chambers. Ethylbloc® was injected into the chambers in the form of solution in required amounts.

The temperature of vaselife room was 20 ±. 2°C, 70 - 80% RH, light intensity was 15 - 20 µmol $s^{-1}m^{-2}$ and photoperiod was 12 h.

In this experiment 6 levels of 1-MCP concentrations (0, 20, 40, 60, 80 and 100 nl l^{-1}) as well as 3 levels of time durations (3, 6 and 9 h) were studied in a factorial randomized complete block design with 3 replications. Altogether, 54 experimental plots with 6 cut carnation per plot were studied.

The features investigated in this study were vaselife, water uptake, loss of chlorophyll index and loss of fresh weight. Vaselife of cut carnations were evaluated in vaselife room. The criterion for determining of vaselife termination for cut carnations was the in-rolling of the petals. Water uptake rate (ml g^{-1} fresh weight) was calculated on the basis of primany weight of the flowers, by the amount of decreasing the preservative solution and room evaporation.

Loss of fresh weight (ml g^{-1} F.W.) was calculated by the following equation:

[(initial fresh weight (g) + amount of water uptake (ml)] – [(final fresh weight (g) + weight of recuts (g)].

Loss of chlorophyll index in leaves of cut carnations was measured with chlorophyll meter SPAD-502 manufactured by Minolta company in 2 stages: after treatment by 1-MCP and at the end of vaselife.

Loss of chlorophyll index was measured by the equation below:

[(chlorophyll index after treatment by 1-MCP) – (chlorophyll index at end of vaselife)].

Data were analyzed using SPSS and MSTATC software. Comparison of mean was carried out using SNK test. Graphs were drawn with excel software.

RESULTS AND DISCUSSION

Vaselife

Among the different 1-MCP concentrations, 60 nl 1^{-1} with average vaselife of 15.49 days was better than other treatments and as compared to the control treatment, it increased the vaselife more than 3.1 days (Table 1). The same treatment increased the vaselife 3.5-4 days for 3 and 6 h with 16.467 and 16 days, respectively, while 40 nl 1^{-1} for 9 h increased the vaselife up to 3.1 days (Figure 1).

According to variance analysis, significant differences were observed among the different treatments in term vaselife ($P \geq 0.01$). Thus, in this study, treatments with 1-MCP markedly extend the vaselife of cut carnations.

Our results were similar to the results obtained by many other investigators (Serek et al., 1995b; Blankenship and Dole, 2003; Ichimura et al., 2002). Ichimura et al. (2002) showed that treatment with 1-MCP doubled the vaselife of cut carnation and concentrations of 0.25, 0.5 and 2 µl l^{-1} extended the vaselife of flowers as much as that at 1 µl l^{-1}. Treatment with 1-MCP at 1 µl l^{-1} extended the vaselife of cut carnation flowers and florets and spikes of cut *Delphinium* by 8 and 1 days, respectively. In sweet pea flowers, treatment with 1-MCP extended the vaselife of florets that opened before the day of harvest by 3 days. But, treatment with 1-MCP did not extend the vaselife of native Australian cut flowers, which are sensitive to ethylene (Macnish et al., 2000).

The studies of Serek and Reid (2000) demonstrated

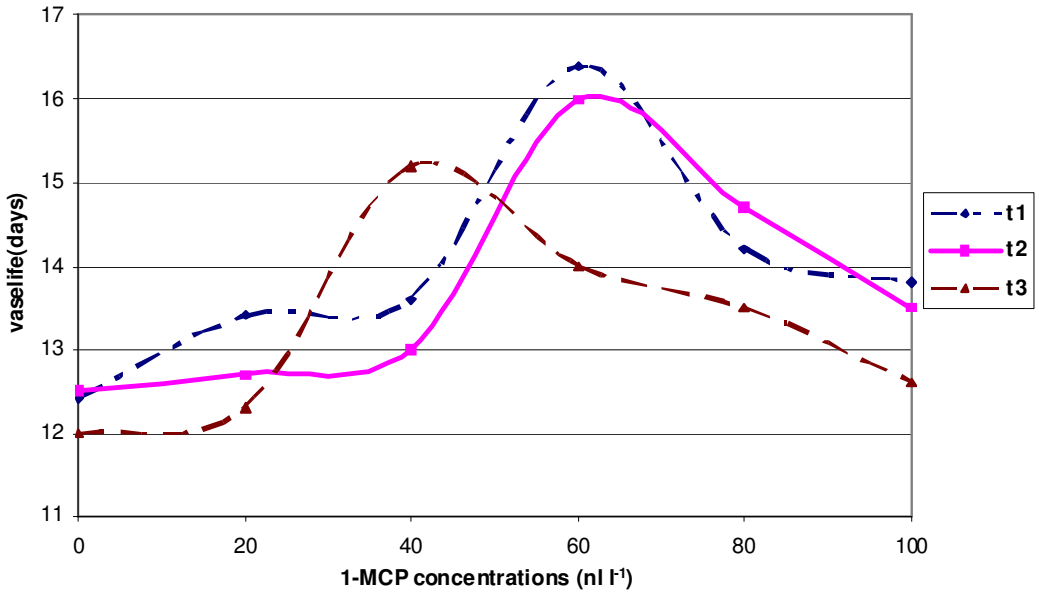

Figure 1. Interaction between concentration and time duration on vaselife of cut carnation.

that treatment with 1-MCP had no effect on the normal life of kalanchoe, although 1-MCP has been shown to prevent the response of kalanchoe flowers to ethylene. In fact, these investigators believe that ethylene does not seem to play any important role in the natural life of these flowers. There was no correlation between the sensitivity to ethylene and the longevity of the flowers. The inhibitory effect of a single 1-MCP exposure is relatively short-lived; for example, 12 - 15 days at 24°C in carnation flowers (Sisler and Serek, 1997).

Serek et al. (1995b) revealed that the pretreatment of cut carnations with 3 nl 1^{-1}1-MCP for 6 h inhibited their normal wilting response. The studies of these researchers indicated that 90% of possible longevity would be achieved with a pretreatment of 10 - 20 nl 1^{-1} 1-MCP.

Untreated cut carnations were wilted 4 days after being placed in the vaselife room, whereas flowers treated with 20 nl 1^{-1} 1-MCP lasted for 7 days. Study on the effect of 0.3, 0.5 and 0.7 gm^{-3} 1-MCP for 3 and 6 h on cut carnation and chrysanthemum showed that all above mentioned concentrations increased the vaselife of cut carnations compared to the control plants. 1-MCP treatment at 0.5 gm^{-3} for 6 h resulted in 14 days vaselife which was significantly superiority to control with 6.67 days vaselife (Fahmy and Hassan, 2005). In chrysanthemum, treatment for 6 h was better than 3 h in all concentrations and 0.5 gm^{-3} for 6 h with 22 days the vaselife was the best (Fahmy and Hassan, 2005).

The spectacular inhibition of the deleterious effects of ethylene in potted plants and cut flowers by pretreatment with 1-MCP indicates that this compound may provide the substitute for other ethylene-action inhibitor, such as DACP and STS. At minute concentrations (< 20 nl 1^{-1}), 1-MCP provided as much protection as an application of STS, preventing ethylene-induced bud and flower abscission (Serek et al., 1995b).

In the current study, treatment time had no significant effect on vaselife but the effect of concentration and interaction between them were significant. Our studies confirmed the results obtained by Serek et al. (1995b). The surface interrelationship between 1-MCP concentration, treatment time and flower longevity indicated an interaction between concentration and time duration. Lower concentrations may be as effective as higher concentrations if the treatment time is extended (Serek et al., 1995b). This result clearly shows that appropriate treatment conditions can be developed for a range of possible treatment regimes (Figure 2).

1-MCP inhibits biosynthesis and ethylene binding to receptors. This binding is irreversible, because after this happen, most of ethylene receptors are blocked and ethylene is inactive (Fahmy and Hassan, 2005). In this experiment also 60 nl 1^{-1} 1-MCP for 3 and 6 h and 40 nl 1^{-1} for 9 h were the best treatments. These results suggest that these concentrations are sufficient for the saturation of ethylene receptors (Jiang et al., 2002b).

In carnation, 1-MCP at higher concentrations is required in old flowers than young flowers to protect them from ethylene action (Sisler et al., 1996a).

Most researchers confirm this theory that effective 1-MCP concentrations depend on time duration and relation between the 2 is converse (Sisler and Serek, 1997).

Water uptake

Treatment time, 1-MCP concentrations and their interaction has significant effects on the water uptake by cut

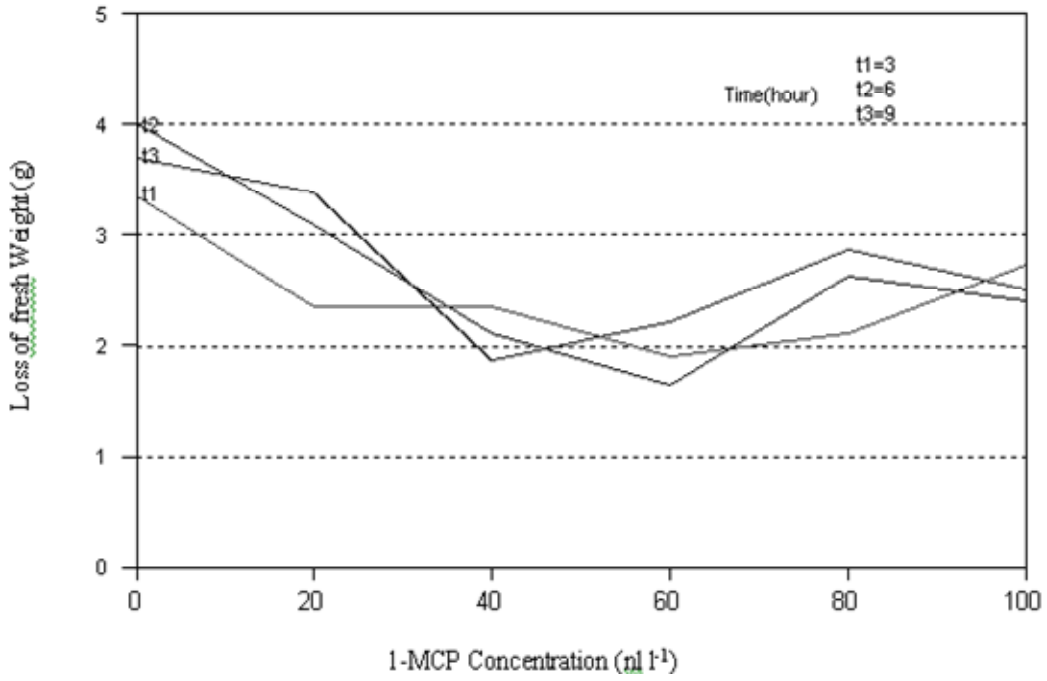

Figure 2. Interaction between concentration and time duration on the loss of fresh weight of cut carnation.

Table 2. The effect of time duration on different characteristics of cut carnation 'Tempo'.

Loss of fresh weight (g)	Loss of chlorophyll index	Water uptake (ml g^{-1} F.W.)	Vaselife (days)	Time duration (h)
2.464 b	7.58 a	2.35 a	14.02 a	3
2.645 ab	6.73 b	2.27 ab	13.77 a	6
2.757 a	7.56 a	2.12 b	13.32 a	9

Mean values with the same letters are not significantly different at 0.05 by S.N.K.

carnations (P ≥ 0-01). Flowers treated with 1-MCP at 60 nl 1^{-1} for 3 h and their interaction with 2.41, 2.35 and 2.57 ml g^{-1} fresh weight of flowers, respectively, had the highest water uptake, while the control plants had the lowest water uptake with 2.01 ml g^{-1} fresh weight (Tables 1, 2 and Figure 3).

The studies of Chamani (2006) on *Rosa* 'First red' cut flowers revealed that the 5 µl 1^{-1} 1-MCP increased water uptake compared to the control and there was a significant difference (P ≥ 0-01) between them. The experiments of Obsuwan and Thairatanakij (2007) on three species of orchids using 0, 250, 500 and 1000 nl 1^{-1} 1-MCP for 1.5 h showed that the plants treated with any concentration of 1-MCP had the more water uptake than that of control. In the other words, control plants had the lowest water uptake. These researchers observed that 1-MCP increased water uptake.

Generally, without the plenty of water, flowers will become wilting after harvesting. In carnation, water stress decreased the postharvest life and the flowers should be placed in the suitable water conditions at temperatures higher than 2°C (Gast, 1997).

Loss of chlorophyll index

Among different 1-MCP concentrations, 60 and 80 nl 1^{-1} with 3.76 and 4.56 loss of chlorophyll index were better than other concentrations (P ≥ 0-01) (Table 1). The effect of interaction between 1-MCP concentrations and time duration on chlorophyll index was significant. Treatment of 60 nl 1^{-1} 1-MCP for 3 h with 2.667 loss of chlorophyll index, was better than other treatments. However, 60 and 80 nl 1^{-1} 1-MCP for 6 h with 3.667 and 3.733 loss of chlorophyll index were good (Figure 4). These findings revealed the ability of 1-MCP in preventing from loss of chlorophyll index.

Fahmy and Hassan (2005) revealed that the use of different 1-MCP concentrations on carnation and chrysanthemum cut flowers led to a significant difference in chlorophyll content of treated and untreated flowers.

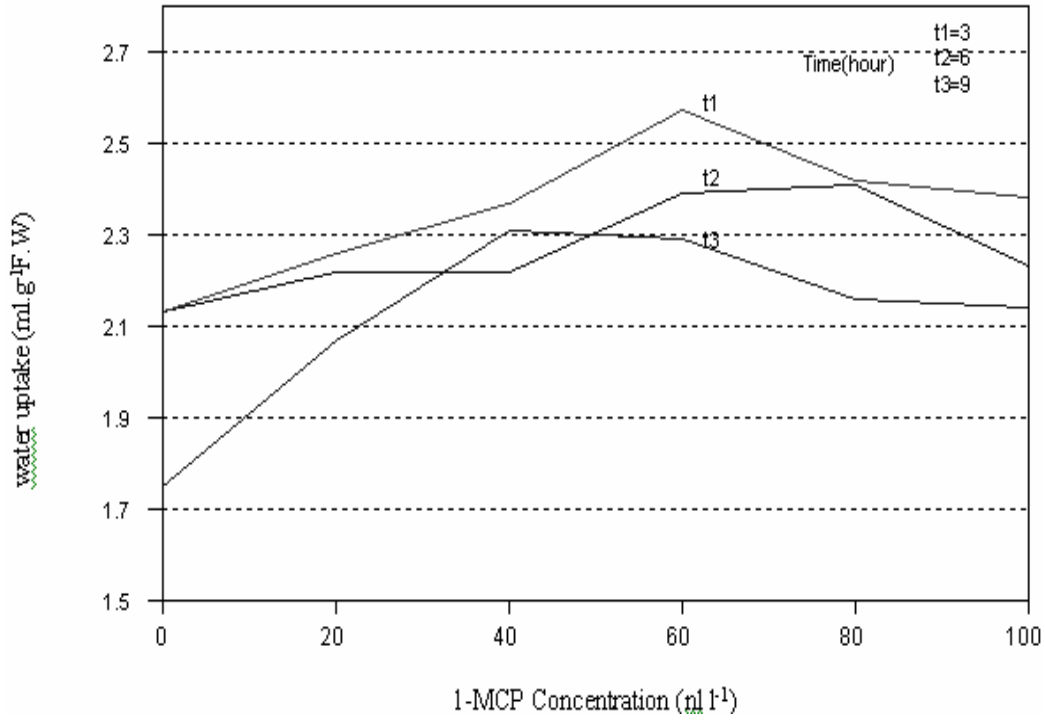

Figure 3. Interaction between concentration and time duration on water uptake of cut carnation.

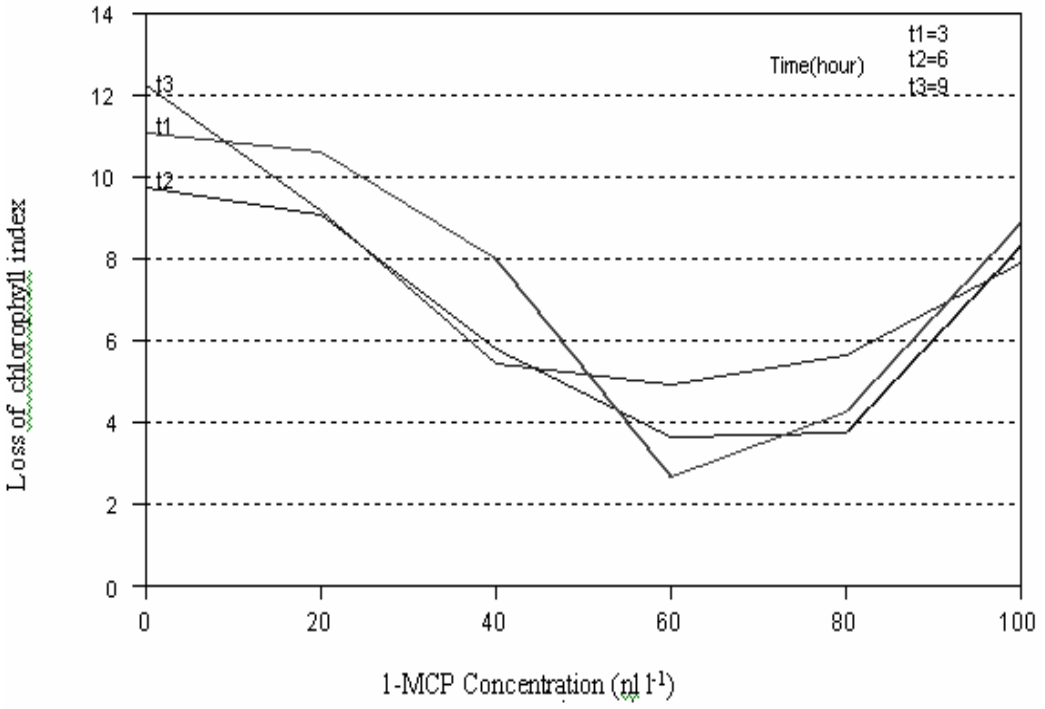

Figure 4. Interaction between concentration and time duration on the loss of chlorophyll of cut carnation.

Untreated flowers, control, lost their chlorophyll rapidly. These researchers observed that the initial chlorophyll contents were 1.83 and 0.75 mg g^{-1} F.W. for chlorophyll a and b, respectively, while these values were 1.2, 0.33,

0.6 and 0.18 mg g^{-1} F.W. for control flowers and flowers treated with 1-MCP, respectively. These results were also obtained in chrysanthemum. At the 9^{th} day of this experiment, 74% of control flowers lost their chlorophyll, while chlorophyll content in flowers treated with 1-MCP was 37% more than that of control flowers.

Much research about the effect of 1-MCP on delay or inhibition of chlorophyll disintegration has been done in many garden products. Porat et al. (1995) showed that 1-MCP prevents from chlorophyll disintegration in orange, but ethylene stimulates that. Feng et al. (2000) revealed that 1-MCP delays the change of avocado peel color. Muller et al. (1998) showed that 1-MCP delays the chlorophyll disintegration in *Codiaeum variegatum* var. pictum in the presence of ethylene. Serek et al. (1998) proposed that 1-MCP is able to prevent the leaves of *Pelargonium* 'Isable' and cuts of *Hibiscus rosa-sinansis* and chrysanthemum from turning yellow. Muller et al. (1997) showed 1-MCP effects on abcission and turning yellow of *Epipremum pinnatum* cuts kept at 23°C for 4 days.

The display life quality and longevity of flowers were improved as a result of 1-MCP application (Fahmy and Hassan, 2005). Pretreatment of potted rose with 1-MCP caused the freshness of leaves and chlorophyll protection.

Jiang et al. (2002b) revealed that 50 $n11^{-1}$ 1-MCP is able to prevent the chlorophyll disintegration in coriander leaves. These researchers examined the 100 and 1000 nl 1^{-1} 1-MCP and showed that there was no significant difference between 100 and 1000 nl 1^{-1}. These findings showed that 100 nl 1^{-1} 1-MCP is enough to block of the ethylene recaptors in coriander leaves.

Loss of fresh weight

The effect of time duration was significant on the loss of fresh weight ($P \geq 0.05$) and 3 h with 2.464 g was better than 6 and 9 h (Table 2). The effect of 1-MCP concentration on the loss of fresh weight was significant ($P \geq 0.01$) and 60 nl 1^{-1} 1-MCP with 3.681 g was better than other 1-MCP concentrations (Table 1). Among the different interaction levels of 1-MCP concentrations and time duration, 60 nl 1^{-1} 1-MCP for 6 h was the best. However, 40 nl 1^{-1} for 9 h, also was better than other treatments.

Porat et al. (1995) showed that 1-MCP had no effect on the loss of fresh weight in orange. The studies of Fahmy and Hassan (2005) on carnation and chrysanthemum demonstrated that the concentrations of 0.3, 0.5 and 0.7 gm^{-3} for 3 and 6 h, minimized the loss of initial fresh weight and improved the quality of cut flowers. In this experiment, the lowest (1.91) and the highest (8.4) loss of fresh weight was recorded in concentrations of 0.5 gm^{-3} 1-MCP for 6 h and control plants, respectively.

Increase in water uptake and decrease in respiration rate, are two important factors for the inhibition of loss of fresh weight in flowers treated with 1-MCP.

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