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AUGMENTATION OF VASE SOLUTION WITH SILVER NANO-PARTICLES AND ESSENTIAL OILS TO PROLONG THE LIFE OF *LILIUM ORIENTALIS* L. CV. SANTANDER CUT FLOWERS

Safia, H., El-Hanafy[1]; Amal, A.M., Nasr[1]; Magda, M., Kandil[2] and Mayada, M., El-Sabwah[2]
[1]Department of Ornamental Horticulture, Faculty of Agric., Cairo University, Giza, Egypt.
[2]Department of Ornamental Plants and Woody Trees, National Research Centre, Dokki, Cairo, Egypt.

Abstract

In a postharvest laboratory experiment, to measure the effectiveness of some eco-friendly or natural substances to extend the vase life of *Lilium orientalis* L. cv. Santander cut spikes, silver nano-particles (SNP) at concentrations of 0, 2.5, 5, 10, 15, and 20 ppm, and essential oils (EOs) of peppermint, cumin, thyme, and cinnamon at concentrations of 0, 150 and 200 μlL^{-1} and mixtures (Peppermint oil [150 μlL^{-1}] + Cumin oil [150 μlL^{-1}] and Thyme oil [150 μlL^{-1}] + Cinnamon oil [150 μlL^{-1}]), were used in two separate experiments at the Ornamental Plants and Wooden Trees Laboratory at the National Research Centre in Dokki, Giza, Egypt, between 23rd November and 15th December in two consecutive years 2014 and 2015. The results of the first experiment revealed that SNP at the concentration of 2.5 ppm was the most efficient in prolonging the vase life of cut Lilium spikes as recorded 18 days in the two years compared to the control, which scored 14.5 days in the 1st year and 15 days in the 2nd year. It was also the most effective in maintaining water balance and relative change of flower fresh weight until the fifth day in the 1st year and till the seventh day in 2nd year. The concentration of 15 ppm SNP registered the highest results in the water uptake and was the first competitor to concentration 2.5 ppm in prolonging the spikes' vase life. On the other hand, all used EOs at the both concentrations as well as mixtures had significant positive effects on extending the spikes' vase life in the two years. Also, all the used EOs and their mixtures were able to significantly increase the water uptake, the water loss, the water balance and the relative change of flower fresh weight of the cut Lilium spikes. The most efficient EOs were thyme oil at the concentration of 200 μlL^{-1}, cinnamon oil in the concentrations of 150 and 200 μlL^{-1} and the first mixture (Peppermint oil [150 μlL^{-1}] + Cumin oil [150 μlL^{-1}]). Thus, it can be said that the harmful chemical preservatives which are used abundantly in floral preservative solutions can be replaced with less hazardous substances and in very low concentrations such as SNP, or safe natural materials such as EOs.

Keywords **:** *Lilium orientalis* L., cut flowers, spikes, postharvest, preservatives, preservative solutions, Sliver nano-particles (SNP), Essential oils (EOs), peppermint oil, cumin oil, thyme oil, cinnamon oil, essential oils mixtures.

Introduction

The Lily bulb belongs to the family Liliaceae; order Liliales and the genus is Lilium. The genus Lilium comprises the true lilies. They produce scaly bulbs, narrow leaves, and individual or clustered flowers of which some are quite odorous, with a diversity of colours (Issak, 2010). Lilium is one of the preferable cut flowers all over the world. Hybrids of asiatic and oriental lilies and *L. longiflorum* are the most promising in florist trade. Oriental lilies are the most expensive among various lily species, and they have a broad agreeability in floral industry, mainly as cut flowers and potted plants (Kumar *et al.*, 2007). Lilium achieved the 6th rank between the top ten cut flowers of the world (Vinodh *et al.*, 2013).

The use of preservative solutions is a common way for the storage of floral stems. Using these preservatives control ethylene synthesis, inhibit pathogen development, preserve plant water and respiration balance, and conserve floral colour, floral bud development and opening, (Reid, 2012).

Silver (Ag+) is the most common and active mineral ion, which acts as a germicide (Jordi *et al.*, 1995). Silver ions have an antiseptic property which is useful for inhibiting microorganism’s growth that eventually increases vase life (Nell, 1992; Jiang *et al.*, 2004). Silver reduces ethylene-binding capacity and restrains cut spikes' endogenous ethylene production, and so it can delay the occurrence of degenerative changes such as early wilting, petal in-rolling and abscission of flowers, petals and buds (Reid, 2012). Improving cut flowers' vase life can be achieved by delaying senescence (caused by ethylene synthesis) via the use of receptor inhibitors such silver thiosulphate (STS) complex (Mutui, 2002). However, taking into consideration of the dangers of the heavy metal silver for human health and natural environment, the use of safe environment friendly compounds is recommended. For that, application of silver nano-particles (SNP) is increasingly diffused (Rostmai and Rahemi, 2011). SNP have higher efficiency in suppressing the activity of microorganisms rather than other silver compounds, due to their high surface area which causes better contact with microorganisms (Rai *et al.*, 2009). In addition to that, SNP work as an antibacterial compound by interfering with bacterial cell membrane permeability and inhibiting DNA multiplication which finally suppresses these microorganisms (Oraei *et al.*, 2011). SNP in different concentrations significantly increased the vase life and water uptake of cut Asiatic lilium *cv.* Tresor (Vinodh *et al.*, 2013). Likewise, Nemati *et al.* (2013) recorded extending in longevity of *Lilium orientalis* cv. Bouquet cut flowers by using SNP, also SNP at 30 ppm showed the highest vase solution uptake, initial fresh weight and lowest bacteria colony during the first two days of vase life.

Essential oils are natural products taken from aromatic plants for their antibacterial, antifungal and antioxidant properties, and then they can be used as natural additives to preserve many crops (Teissedre *et al.*, 2000; Thwala *et al.*, 2013). Gogoi *et al.* (1997) attributed the antimicrobial mechanism of essential oils to the synthetic inhibition of DNA, RNA, protein and polysaccharides. Also these antibacterial properties may refer to the high levels of phenolic compounds such as carvacrol, thymol and eugenol (Lambert *et al.,* 2001; Bounatirou *et al.*, 2007; Sharififar *et al.*, 2007; Solgi *et al.,* 2009; Mihajilov-Krstev *et al.*, 2010). El-Hanafy (2007) was the first researcher who tested the effect of essential oils on carnation flowers. She found that cumin, thyme, parsley, peppermint, seville orange and melissa oils at a concentration of 200 ppm prolonged vase life, lowered the pH of vase solution, and limited the bacterial count. Menthol is the main component of Peppermint (*Mentha piperita*). The essential oils of it show strong antibacterial activity (Awang, 1998; Ernestt and Pittler, 2001; Işcan *et al.*, 2002). Peppermint oil markedly decreased preservative solution pH, whilst significantly increased carotenoid level in gerbera cut flowers (Babarabie *et al.*, 2017). Essential oils of Black cumin (*Bunium persicum*) also have strong anti-bacterial effects. This can be attributed to the relatively high amount of terpinenes and cumin aldehyde in the essential oil (Moghtader *et al.*, 2009). Thyme (*Thymus vulgaris*) oil, which contains phenolic compounds, is considered to have antibacterial, antimycotic and antioxidative properties (Deans and Ritchie, 1987; Deans *et al.*, 1993). Its major components were thymol, carvacrol and borneol (Jakiemiu *et al.,* 2010). It was found that the thyme oil was more toxic to many pathogenic fungi, and it was fungistatic at 250 ppm and had fungicidal activity at 500 ppm (Soliman and Badeaa, 2002). Thymol (isolated from zataria) at 200 mgL^{-1} could significantly prolong the vase life, maintain the fresh weight and improve the solution uptake of gerbera cut flowers (Babarabie *et al.*, 2017). Cinnamon (*Cinnamomum verum*) oil significantly decreased the microbial density, spike base rot, deteriorated florets, deteriorated/opened florets percentage and spike fresh weight losses percentage, while increased spike vase life, water uptake, number of opened florets and total carbohydrates of cut gladiolus spikes (Hegazi and El-Kot, 2009). The oils of cinnamon and thyme have more effect on fungal development and subsequent mycotoxin production (Soliman and Badeaa, 2002).

Therefore, this study was carried out to determine the effect of nanosilver particles and some essential oils on elongating the vase life and some other quality parameters of *Lilium orientalis* L. cv. Santander cut spikes.

Material and Methods

Location and Duration

The experiment trials were consummated during the period from 23rd of November to 15th of December, in two consecutive seasons in 2014 and 2015, at laboratory of Ornamental Plants and Woody Trees Department, National Research Centre, Dokki, Giza, Egypt and Ornamental Horticulture Department, Faculty of Agriculture, Cairo University.

Plant Material

Lilium orientalis L. cv. Santander cut flowers obtained from a commercial grower (Floramix Farm) in Giza, Egypt. Lilium cut flowers were harvested when they were mature and before opening. The flowers were pre-cooled to alleviate the effect of high field temperature, and wrapped in kraft paper in groups, each involving 10 flowers. The flowers were transported immediately from the farm to laboratory of Ornamental Plants and Woody Trees Department, National Research Centre. All Lilium spikes were cut off under tap water in order to avoid air embolism to a standard length of 80 cm, lower leaves were removed to reduce contamination and water loss.

Silver nano-particles (SNP)

They were procured from Segma-Aldrich Company, USA. They were in the form of silver nanopowder <100 nm particle size.

Essential oils

Essential oils used in the experiment were secured from Squeezing and Extracting Natural Oils Unit, National Research Centre, Dokki, Giza. They were extracted by steam distillation method.

Procedures and Treatments

Every flower was put in a separate graduated cylinder having 500 ml of holding solution. The flowers were divided into two experiments as follows:

(1) First experiment, silver nanoparticles (SNP)

a. Control
b. Silver nano-particles (2.5, 5, 10, 15 and 20 ppm)

(2) Second experiment, Essential oils (EOs)

a. Control
b. Peppermint oil (150 and 200 μlL^{-1})
c. Cumin oil (150 and 200 μlL^{-1})
d. Thyme oil (150 and 200 μlL^{-1})
e. Cinnamon oil (150 and 200 μlL^{-1})
f. Peppermint oil (150 μlL^{-1}) + Cumin oil (150 μlL^{-1})
g. Thyme oil (150 μlL^{-1}) + Cinnamon oil (150 μlL^{-1})

The layout of the two experiments was completely randomized design. Each treatment had four replicates and one cut flower rachis was used for each replicate. The control rachis was placed in distilled water in first experiment and distilled water with two drops of tween 20 in the second experiment.

Assessment of vase life

(1) Longevity of vase life of cut spikes (days)

This was recorded from the day of anthesis of the first floret (the day of harvesting) to the day of senescence of the last floret (according to Nowak and Mynett, 1985).

(2) Change of weight of cut spikes relative to the fresh weight (R.F.W.)

The fresh weight of spikes (F.W.) was recorded day after day during the vase period and its relative changes (in relation to the fresh weight on the day of harvesting) was calculated from the formula: R.F.W. (%) = $(W_t/W_{t=0})\times100$; where, W_t (in grams) is the weight of the spike at particular day (t= 3, 5, 7, etc.) and $W_{t=0}$ is the fresh weight of the spike (on the day of harvesting) in grams (He *et al.*, 2006).

(3) Water uptake, total water uptake and daily water uptake

The readings of the graduated cylinders were recorded day after day during the vase period. Water uptake was calculated by the formula: Water uptake = R_t-R_{t+2}; where, R_t is the cylinder reading at day 0, 3, 5, etc., and R_{t+2} is the cylinder reading after two days. The total water uptake was the sum of the water uptake of the spike during the vase life, while the daily water uptake was calculated by dividing the total water uptake on the vase life of the spike.

(4) Water loss, total water loss and daily water loss

Every two days, the weight of cylinders (WC) and the weight of spikes (WF) were recorded. Water loss was calculated by the formula: Water loss = (WC_t-WC_{t+2})-(WF_t-WF_{t-2}); where, WC_t is the cylinder weight at day 0, 3, 5, etc., WC_{t+2} is the cylinder weight after two days, WF_t is the spike weight at day 3, 5, 7, etc., and WF_{t-2} is the weight of spikes after two days. The total water loss was the sum of the water loss of the spike during the vase life. The daily water uptake was calculated by dividing the total water loss on the vase life of the spike.

(5) Water balance, total water balance and daily water balance

Water balance was calculated by the formula: Water balance = water uptake-water loss, every two days during the vase life of the spike. The total water balance was the sum of the water balance of the spike during the vase life, whereas the daily water balance was calculated by dividing the total water balance on the vase life of the spike.

Statistical analysis

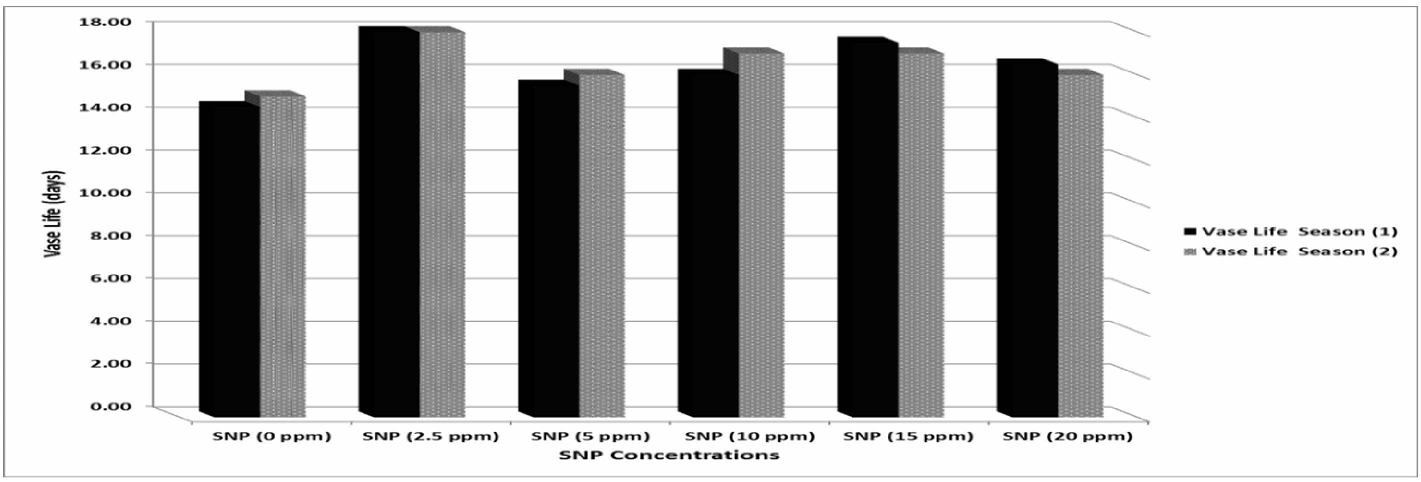
Data on vegetative growth and some chemical constituents in the two years were statistically analyzed as described by Snedecor and Cochran (1980). Means of all characters were compared by L.S.D. test at 0.05 level of significance.

Results and Discussion

First experiment, Silver nanoparticles (SNP)

(1) Vase life (days)

Data presented in Fig. (1) reveal that all the SNP concentrations significantly increased the vase life of the cut Lilium spikes compared to the control (14.5 days in the 1st year and 15 days in the 2nd year). The concentration 2.5 ppm recorded the highest vase life in the two years (18 days). These results agree with those achieved by Nemati *et al.* (2013) on *Lilium orientalis* 'Bouquet' and Vinodh *et al.* (2013) on *Asiatic lilium* cv. Tresor. They attributed these results to the high surface area of SNP particles that enable their contact with more microorganisms (Rai *et al.*, 2009). On the other hand Beni *et al.* (2013) on *Polianthus tuberosa* cv. Single and Seleem (2014) on *Gladiolus grandiflorus* L. had their results with the same trend. The lowest concentration of SNP has the most significant effect on vase life. Van Ieperen *et al.* (2000) attributed these results to the phytotoxic effect of SNP that accompanies the increase in concentration. Nair *et al.* (2010) stated that the very high concentration produced some chemical injuries on the plant tissues.

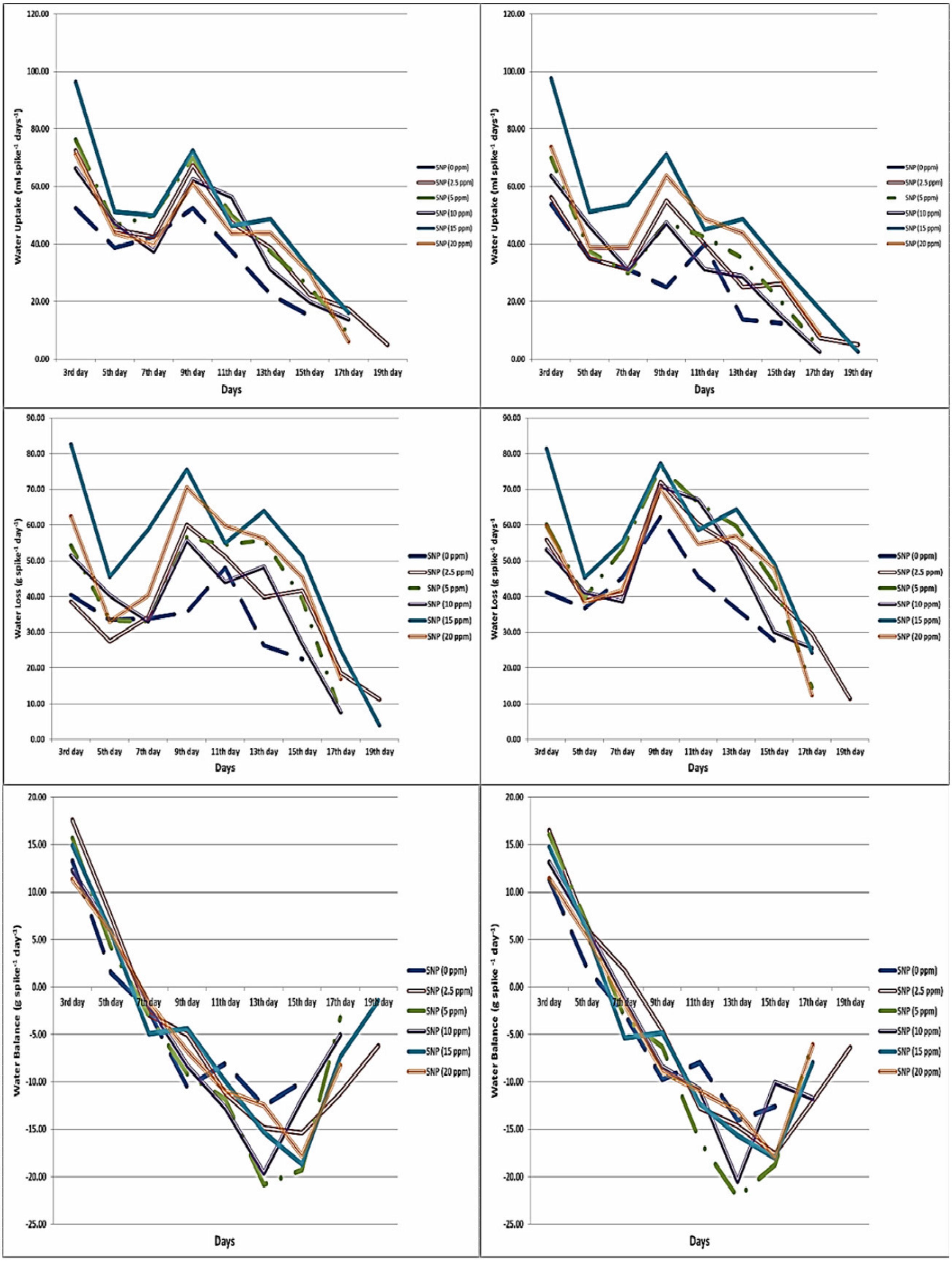


SNP: Silver nano-particles

Fig. 1 : The effect of SNP on vase life of cut *Lilium orientalis* L. cv. Santander spikes during 2014 and 2015 years.

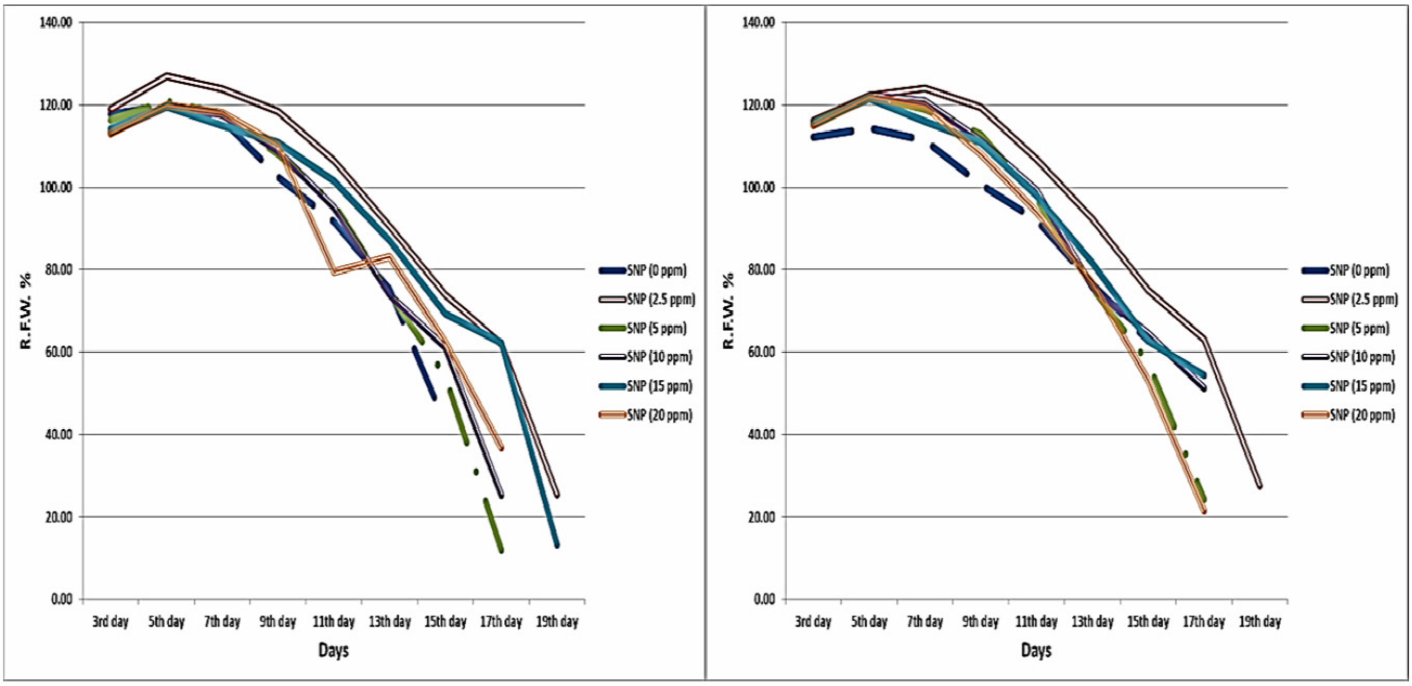
(2) Water relations

The results in Fig. (2) and Tables (1, 2 and 3) reveal that the concentration of 15 ppm SNP has the highest water uptake and water loss whether being measured daily or at two days intervals a long the all vase life. This trend is not followed in water balance, whereas the concentration of 2.5 ppm SNP recorded the highest water balance in the most days during the vase life. However, control cut lilium spikes registered the highest total and daily water balance in the two years, other than the control there is no significant effect on total water balance among the different concentrations of SNP in the two years. But regarding the daily water balance, 2.5 ppm SNP scored the best result among the different concentrations of SNP in the two years. These results are similar with those obtained by Vinodh *et al.* (2013) on Asiatic lilium cv. Tresor, where they attributed the long vase life to the balance between the water uptake and the water loss that increased by using SNP in different concentrations, because of the high efficiency of SNP in suppressing microorganisms, so the vessels still opened and water uptake increased.



SNP: Silver nano-particles

Fig. 2 : The effect of SNP on water uptake, water loss and water balance of cut *Lilium orientalis* L. cv. Santander spikes during 2014 and 2015 years.



SNP: Silver nano-particles.

Fig. 3 : The effect of SNP on relative change of flower fresh weight of cut *Lilium orientalis* L. cv. Santander spikes during 2014 and 2015 years.

(3) Change of weight of cut spikes relative to the fresh weight (R.F.W.)

Data presented in Fig. (3) display that in all treatments the cut lilium spikes gained weight till the fifth day then began to lose weight during the vase life, except for the concentration of 2.5 ppm in the second year, the cut lilium spikes gained weight until the seventh day before they began to lose weight. The rate of weight reduction of the cut spikes is lower in SNPs solutions than control. The concentration of 2.5 ppm SNP scored the highest relative change of spike fresh weight in all days during the vase life and was the most efficient concentration in maintaining the fresh weight of the cut lilium spikes. These results are similar to those achieved by Nemati *et al.* (2013) on *Lilium orientalis* "Bouquet", who found that SNPs solution delayed the reduction of the cut lilium flowers and kept the fresh weight of them at high values.

From all the above, it can be concluded that although the concentration of 2.5 ppm SNP didn't have a high impact on spikes' water uptake with different SNP concentrations, but it was the most efficient concentration in maintaining the equilibrium between the water absorbed and water lost in cut lilium spikes. It was also the best concentration in maintaining the fresh weight of lilium cut spikes until the end of their vase life. Therefore the concentration of 2.5 ppm SNP had the highest vase life in two years.

Table 1 : The effect of SNP on total and daily water uptake of cut *Lilium orientalis* L. cv. Santander spikes during 2014 and 2015 years.

Treatments	Total Water Uptake (ml spike^{-1})		Daily water Uptake (ml spike^{-1} day^{-1})	
	1st year	2nd year	1st year	2nd year
SNP 0 ppm	211.25^{e}	261.25^{d}	14.60^{d}	17.42^{d}
SNP 2.5 ppm	281.25^{cd}	358.75^{bc}	15.65^{d}	19.96^{c}
SNP 5 ppm	286.25^{c}	363.75^{b}	18.50^{c}	22.79^{ab}
SNP 10 ppm	266.25^{d}	335.00^{c}	16.73^{cd}	19.71^{c}
SNP 15 ppm	420.00^{a}	412.50^{a}	24.05^{a}	24.26^{a}
SNP 20 ppm	343.75^{b}	340.00^{bc}	20.93^{b}	21.98^{b}

Table 2 : The effect of SNP on total and daily water loss of cut *Lilium orientalis* L. cv. Santander spikes during 2014 and 2015 years.

Treatments	Total Water Loss (g spike^{-1})		Daily water Loss (g spike^{-1} day^{-1})	
	1st year	2nd year	1st year	2nd year
SNP 0 ppm	240.11^{e}	295.19^{d}	16.57^{d}	19.68^{d}
SNP 2.5 ppm	322.94^{cd}	402.36^{bc}	17.97^{cd}	22.38^{c}
SNP 5 ppm	333.65^{c}	413.46^{b}	21.56^{b}	25.89^{a}
SNP 10 ppm	307.42^{d}	378.21^{c}	19.30^{c}	22.25^{c}
SNP 15 ppm	461.33^{a}	455.91^{a}	26.40^{a}	26.82^{a}
SNP 20 ppm	384.50^{b}	382.11^{c}	23.39^{b}	23.92^{b}

Table 3 : The effect of SNP on total and daily water balance of cut *Lilium orientalis* L. cv. Santander spikes during 2014 and 2015 years.

Treatments	Total Water Balance (g spike^{-1})		Daily water Balance (g spike^{-1} day^{-1})	
	1st year	2nd year	1st year	2nd year
SNP 0 ppm	-28.86^{a}	-33.94^{a}	-1.98^{a}	-2.26^{a}
SNP 2.5 ppm	-41.69^{b}	-43.61^{b}	-2.31^{ab}	-2.42^{a}
SNP 5 ppm	-47.40^{b}	-49.71^{b}	-3.06^{c}	-3.10^{b}
SNP 10 ppm	-41.17^{b}	-43.21^{b}	-2.57^{b}	-2.54^{a}
SNP 15 ppm	-41.33^{b}	-43.41^{b}	-2.35^{b}	-2.55^{a}
SNP 20 ppm	-40.75^{b}	-42.11^{b}	-2.46^{b}	-2.62^{a}

SNP: Silver nano-particles
Means in the same column followed by the same letter are not significantly different by LSD test (α=5%).

Second experiment, essential oils (EOs)

(1) Vase life (days)

As shown in Fig. (4) all the used EOs in different concentrations significantly increased the cut Lilium spikes vase life as compared to the control. The highest increase was in the vase solutions contained thyme oil at the concentration of 200 µlL^{-1}, and cinnamon oil at the concentration of 150 µlL^{-1} where the vase life of cut Lilium spikes extended to 17 days in the two years. On the other hand, there was no significant difference between the two mixtures (Peppermint oil 150 µlL^{-1} + Cumin oil 150 µlL^{-1} and Thyme oil 150 µlL^{-1} + Cinnamon oil 150 µlL$^{-1)}$ on the vase life of cut Lilium spikes.

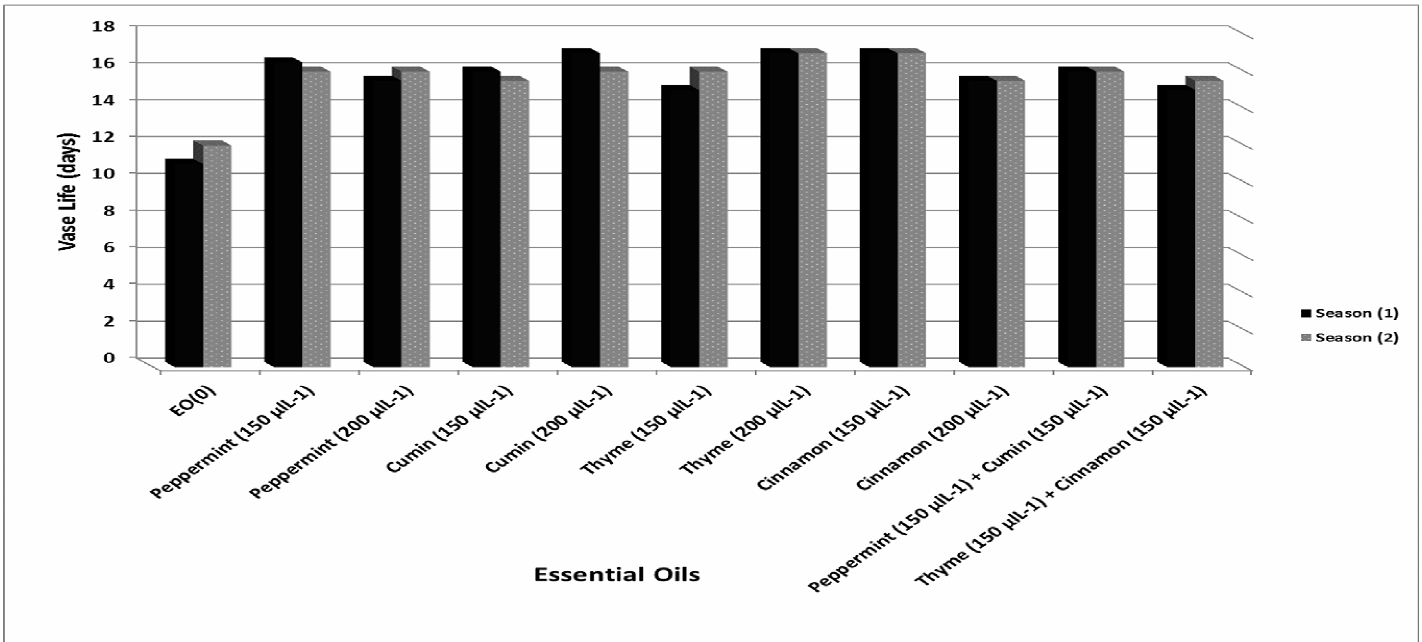
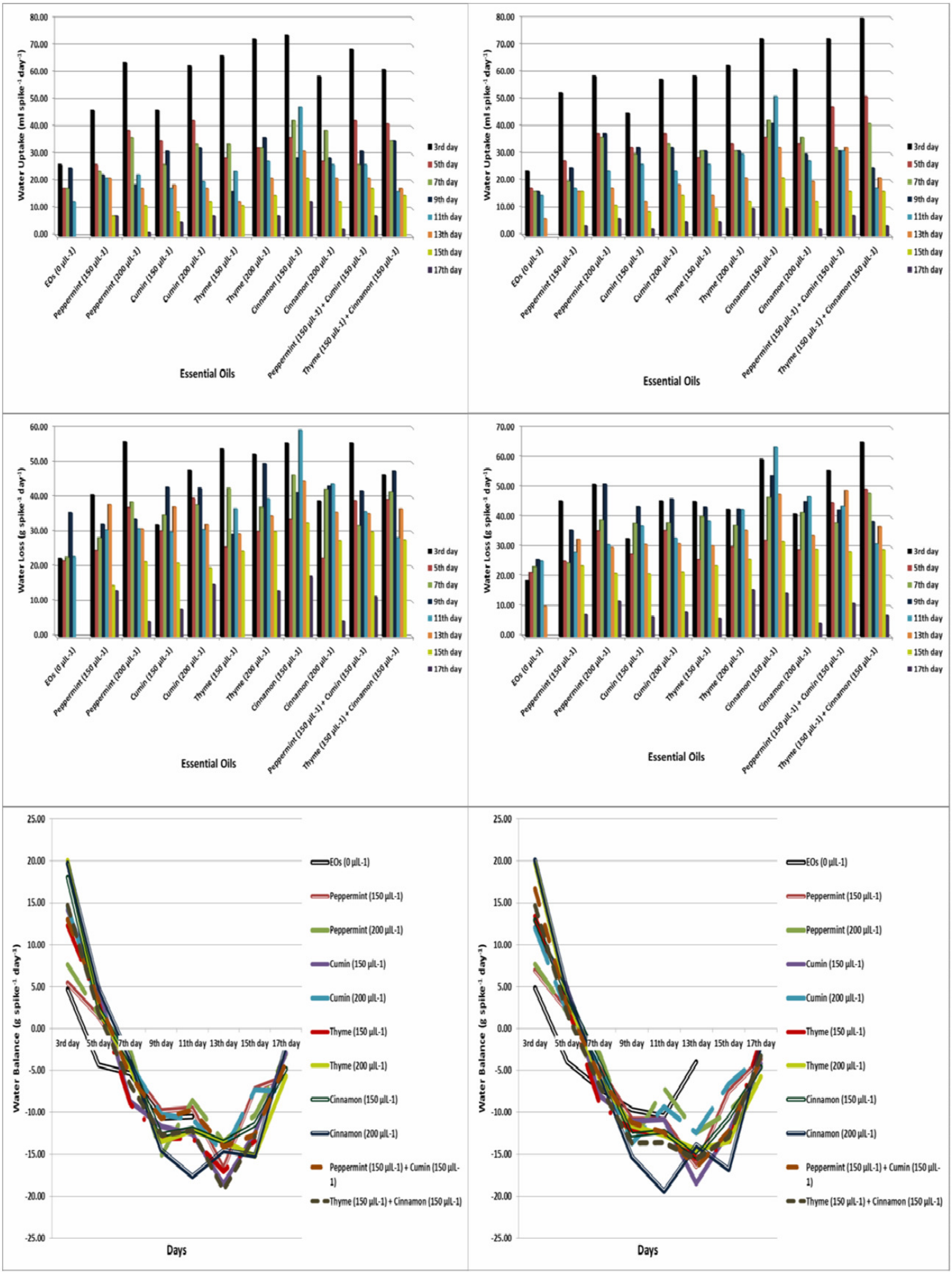


Fig. 4 : The effect of different EOs on the vase life of cut *Lilium orientalis* L. cv. Santander spikes during 2014 and 2015 years.

(2) Water relations

It is clear from data presented in Fig. (5) and Tables (4), (5) and (6) that, all EOs used in the experiment in all their concentrations significantly increased both the water uptake and the water loss as well as the water balance. This increase fluctuated between the different EOs during the spikes' vase life in the two years. Cinnamon oil at the concentration of 150 µlL^{-1} had the highest results compared to other oils and the control in the two years.

The mixture of Peppermint oil 150 µlL^{-1} + Cumin oil 150 µlL^{-1} was significantly associated with higher total and daily water uptake than the other mixture of Thyme oil 150 µlL^{-1} + Cinnamon oil 150 µlL^{-1} in the 1st year while there were no significant differences between the two used EOs mixtures in the second year. However, there were no significant differences between the effects of the two used EOs mixtures in the total and the daily water loss. As for the water balance, it is noticeable that it began in the imbalance and negativity from the fifth day in the control cut spikes in the two years, while with all EOs treatments negativity began from the seventh day. The total water balance was higher in the control due to its low vase life. In the treatments, they were close to each other, but the highest value was in cumin oil at a concentration of 200 µlL^{-1} in the two years. For the daily water balance, cumin oil 200 µlL^{-1} had the highest results in both years. The mixture of Peppermint oil 150 µlL^{-1} + Cumin oil 150 µlL^{-1} was significantly associated with higher total and daily water balance than the other mixture of Thyme oil 150 µlL^{-1} + Cinnamon oil 150 µlL^{-1} in the two years.



EOs: Essential oils

Fig. 5 : The effect of different EOs on water uptake, water loss and water balance of cut *Lilium orientalis* L. cv. Santander spikes during 2014 and 2015 years.

Table 4 : The effect of different EOs on total and daily water uptake of cut *Lilium orientalis* L. cv. Santander spikes during 2014 and 2015 years.

Treatments	Total Water Uptake (ml spike^{-1})		Daily water Uptake (ml spike^{-1} day^{-1})	
	1st year	2nd year	1st year	2nd year
EOs (0 µlL^{-1})	98.75^{f}	95.00g	8.98^{g}	7.90^{g}
Peppermint (150 µlL^{-1})	176.25^{e}	178.75^{f}	10.67^{f}	11.17^{f}
Peppermint (200 µlL^{-1})	210.00^{d}	228.75c^{d}	13.58^{cd}	14.32^{c}
Cumin (150 µlL^{-1})	188.75^{e}	190.00^{ef}	11.83^{ef}	12.25^{e}
Cumin (200 µlL^{-1})	228.75^{bc}	223.75^{cd}	13.46^{cd}	13.59^{cd}
Thyme (150 µlL^{-1})	192.50^{e}	206.25^{de}	12.83^{de}	12.94^{de}
Thyme (200 µlL^{-1})	245.00^{b}	232.50^{c}	14.41^{bc}	13.68^{cd}
Cinnamon (150 µlL^{-1})	293.75^{a}	307.50^{a}	17.28^{a}	18.09^{a}
Cinnamon (200 µlL^{-1})	216.25^{cd}	223.75^{cd}	13.97^{bcd}	14.44^{c}
Peppermint (150 µlL^{-1}) + Cumin (150 µlL^{-1})	241.25^{b}	271.25^{b}	15.13^{b}	16.97^{b}
Thyme (150 µlL^{-1}) + Cinnamon (150 µlL^{-1})	221.25^{cd}	256.25^{b}	14.75^{bc}	16.53^{b}

Table 5 : The effect of different EOs on total and daily water loss of cut *Lilium orientalis* L. cv. Santander spikes during 2014 and 2015 years.

Treatments	Total Water Loss (g spike^{-1})		Daily water Loss (g spike^{-1} day^{-1})	
	1st year	2nd year	1st year	2nd year
EOs (0 µlL^{-1})	124.93^{g}	125.38^{f}	11.36^{g}	10.44^{f}
Peppermint (150 µlL^{-1})	222.95^{f}	223.65^{e}	13.49^{f}	13.98^{e}
Peppermint (200 µlL^{-1})	253.88^{cde}	270.90^{c}	16.40^{cd}	16.94^{bc}
Cumin (150 µlL^{-1})	236.84^{ef}	237.91^{de}	14.83^{e}	15.33^{d}
Cumin (200 µlL^{-1})	266.13^{bc}	259.83^{cd}	15.65^{de}	15.78^{cd}
Thyme (150 µlL^{-1})	242.72^{def}	254.20^{cd}	16.18^{d}	15.94^{cd}
Thyme (200 µlL^{-1})	287.35^{b}	273.17^{c}	16.90^{bcd}	16.07^{cd}
Cinnamon (150 µlL^{-1})	331.68^{a}	350.25^{a}	19.51^{a}	20.60^{a}
Cinnamon (200 µlL^{-1})	259.14^{cd}	271.84^{c}	16.74^{bcd}	17.53^{b}
Peppermint (150 µlL^{-1}) + Cumin (150 µlL^{-1})	281.70^{b}	313.80^{b}	17.65^{bc}	19.63^{a}
Thyme (150 µlL^{-1}) + Cinnamon (150 µlL^{-1})	268.37^{bc}	305.85^{b}	17.89^{b}	19.73^{a}

Table 6 : The effect of different EOs on total and daily water balance of cut *Lilium orientalis* L. cv. Santander spikes during 2014 and 2015 years.

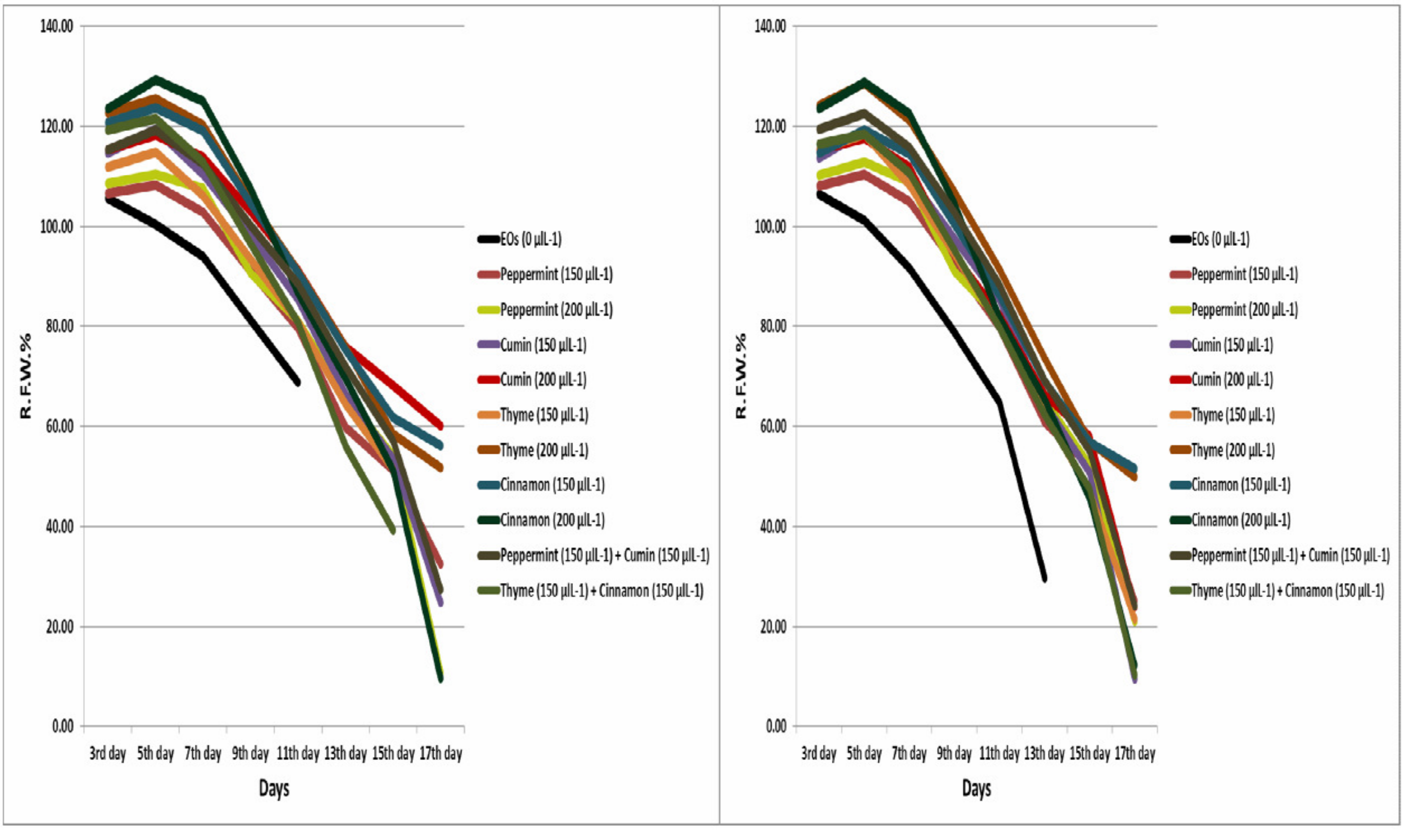
Treatments	Total Water Balance (g spike^{-1})		Daily water Balance (g spike^{-1} day^{-1})	
	1st year	2nd year	1st year	2nd year
EOs (0 µlL^{-1})	-26.18^{a}	-30.38^{a}	-2.38^{a}	-2.54bc
Peppermint (150 µlL^{-1})	-46.70^{cd}	-44.88^{cd}	-2.82^{bc}	-2.81^{cd}
Peppermint (200 µlL^{-1})	-43.88^{bcd}	-42.15^{bcd}	-2.82^{bc}	-2.62^{bc}
Cumin (150 µlL^{-1})	-48.09^{cd}	-47.91^{cd}	-3.00^{cd}	-3.09^{de}
Cumin (200 µlL^{-1})	-37.38^{b}	-36.08^{ab}	-2.20^{a}	-2.19^{a}
Thyme (150 µlL^{-1})	-50.22^{d}	-47.95^{cd}	-3.35^{d}	-3.01^{de}
Thyme (200 µlL^{-1})	-42.35^{bcd}	-40.67^{bc}	-2.49^{ab}	-2.39^{ab}
Cinnamon (150 µlL^{-1})	-37.93^{b}	-42.75^{bcd}	-2.23^{a}	-2.51^{bc}
Cinnamon (200 µlL^{-1})	-42.89^{bcd}	-48.09^{cd}	-2.77^{bc}	-3.10^{de}
Peppermint (150 µlL^{-1}) + Cumin (150 µlL^{-1})	-40.45^{bc}	-42.55^{bcd}	-2.52^{ab}	-2.66^{bc}
Thyme (150 µlL^{-1}) + Cinnamon (150 µlL^{-1})	-47.12^{cd}	-49.60^{d}	-3.14^{cd}	-3.19^{e}

EOs: Essential oils

Means in the same column followed by the same letter are not significantly different by LSD test (α=5%).

(3) Change of weight of cut spikes relative to the fresh weight (R.F.W.)

Data in Fig, (6) show that, the control cut Lilium spikes experienced a rapid reduction in their weight from the fifth day, and then a rapid decline in their weight until the end of their vase life. All the used EOs in their different concentrations were able to make spikes gain weight until the fifth day before they started to decrease in their weight gradually from the seventh day. All used EOs slowed the rate of this reduction until the end of the vase life. Also all treatments increased the relative change of spike fresh weight of the cut spikes compared to the control throughout the vase life. In general, the most efficient essential oils in increasing the relative change of spike fresh weight were thyme oil at the concentration of 200 µlL^{-1} and cinnamon oil at the concentrations of 150 and 200 µlL^{-1} during the spikes' vase life and in the two years. The first mixture Peppermint oil [150 µlL^{-1}] + Cumin oil [150 µlL^{-1}] in most days, especially the last few days, exceeded the second mixture (Thyme oil [150 µlL^{-1}] + Cinnamon oil [150 µlL^{-1}]) in relatively increasing the relative change of spike fresh weight of the cut spikes in the two years.



EOs: Essential oils; R.F.W: Relative fresh weight

Fig. 6 : The effect of different EOs on R.F.W % of cut *Lilium orientalis* L. cv. Santander spikes during 2014 and 2015 years.

Our results are similar to those obtained by many researchers such as: El-Hanafy (2007) who found that cumin, thyme, and peppermint oils at a concentration of 200 ppm prolonged the carnation vase life; Kazemi and Ameri (2012a and 2012b) and Kazemi *et al.* (2012) who recorded that thyme oil prolonged the vase life of lisianthus and carnation cut flowers, although the thyme oil enhanced carnation water uptake, relative solution uptake and relative fresh weight; thyme oil achieved the same results with carnation by Zadeh and Mirzakhana (2012) and with rose cut flowers by Kavosiv *et al.* (2013) whereas thyme oil signicantly affected their vase life, relative solution uptake and relative fresh weight; likewise, Babarabie *et al.* (2017) mentioned that thymol isolated from zataria extended vase life of gerbera cut flowers and increased their solution uptake and relative fresh weight at concentration of 200 mgL^{-1}; also Hegazi and El-Kot (2009) stated that Cinnamon oil significantly decreased cut gladiolus spikes fresh weight percentage loss and increased their vase life and water uptake. All researchers attributed the effects of EOs to their antibacterial, antifungal and antioxidant properties. The antimicrobial mechanism of EOs refers to the synthetic inhibition of DNA, RNA, protein and polysaccharides, as well the high levels of phenolic compounds such as carvacrol, thymol and eugenol (Gogoi *et al.,* 1997; Lambert *et al.,* 2001; Bounatirou *et al.*, 2007; Sharififar *et al.*, 2007; Solgi *et al.,* 2009; Mihajilov-Krstev *et al.*, 2010). These effects were also imputed to the ability of EOs to lower the vase solution pH (El-Hanafy, 2007; Babarabie *et al*., 2017).

Conclusion

A long the last few decades there has been suffering from many harmful chemicals and pollutant. So we have recourse to environmentally friendly or natural materials which have no side effects or residues that cause pollution and are difficult to get rid of. Therefore, in this work, we studied the effect of SNP and some EOs on the vase life of cut *Lilium orientalis* L. cv. Santander spikes. According to the results of this study, we can recommend the use of SNP at the concentration of 2.5 ppm, and essential oils of peppermint, cumin, thyme and cinnamon in concentrations of 150 and 200 µlL^{-1} and their mixtures (Peppermint oil 150 µlL^{-1} + Cumin oil 150 µlL^{-1} and Thyme oil 150 µlL^{-1} + Cinnamon oil 150 µlL^{-1}), to prolong the vase life of the cut Lilium spikes and improve their water relations and relative change of flower fresh weight. In particular, thyme oil at the concentration of 200 µlL^{-1}, cinnamon oil at the concentrations of 150 and 200 µlL^{-1} and Peppermint oil 150 µlL^{-1} + Cumin oil 150 µlL^{-1} mixture can be highly recommended for getting the best results.

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