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Postharvest management and Antibacterial effect of essential oils and sliver based biocides on vase life of cut carnation "Dark Dona"

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Abstract
This experiment was carried out to investigate the effect of different essential oils used for pulsing on vase life senescence of cut carnation spikes. Uniform spikes of cut carnation at paint brush stage were brought to the laboratory and kept in 15 different pulsing solutions consisted of lavender oil, rosemary oil, sage oil each at (100 & 200 ppm), Sucrose (5%) and silver thiosulphate (0.5mM) alone or in combination. Distilled water without any chemical served as control. Among the individual treatments lavender (200ppm) + Sucrose (5%) + STS (0.5mM) maintained better water relations i.e. water uptake, water loss, water balance, water loss/ water uptake ratio, fresh weight changes, vase life and lavender oil showed highest antimicrobial effect ascompared to others

Keywords: carnation, essential oils, sucrose, STS, vase life

Introduction

Carnation (*Dianthus caryophyllus* L.), a member of family Ca yophyllaceae is one of the leading cut flower crops in the world flower trade. It is being extensively cultivated for last 2000 years and is considered to be the native of Mediterranean region. Carnation is the national flower of Spain. It is a herbaceous perennial plant which may grow to a height of 80 cm. The leaves are glaucous greyish green to blue-green, up to 15 cm long. The flowers are produced singly or together in a cyme, they are 3-5 cm in diameter, and sweetly scented. Carnation was traditionally prescribed in European herbal medicine to treat coronary and nervous disorders (Mc George & Hammett 2002) [20] and fevers (Bown, 1995) [2]. In Spain and North America, the flowers have been considered to be alexiteric (counteracting the effects of poison), antispasmodic (counteracting spasms of smooth muscle, usually in the gastrointestinal tract), cardiotonic (having a favourable effect on the heart), diaphoretic (promoting sweating) and nervine (acting therapeutically on the nerves) (Chopra *et al*. 1956) [5].

Carnation is very popular in floristry trade because of its beautiful flowers shape with availability of large range of colours accompanied by a desired attribute of better vase life. However the vase-life of cut-flowers is influenced by improving both preharvest and postharvest management. Proper supply of nutrients, moisture, light, temperature, CO_2 and humidity to the plants during growth period is necessary for obtaining quality flowers (Mayak *et al*., 1978) [18]. Deficiency of potassium causes reduction in water uptake and tolerance to ethylene. Flowers of K-deficient plants show shorter vase-life (Halevy, 1976) [1]. Flowers of carnation are highly sensitive to ethylene. Ethylene accelerates senescence and sleepiness of flowers. Senescence in carnation flowers involves manifold rise in the production of ethylene, enrolling of corolla, growth of gynoecium and eventual death (Ho and Nichols, 1975) [13]. The events leading to death of flowers are often regulated by the growth of gynoecium which has been found to enlarge during senescence. The enlargement of gynoecium creates a competition for the limited source of food supply and because of its strong sink effect the gynoecium dominates other parts leading to the enrolling of petals and to its eventual death.

Microbial growth in preservative solutions could be checked by the addition of 200-1000 ppm8-HQC but at higher concentration 8-HQC causes petal injuries in cut flowers. Application of sodium benzoate (100ppm) controls slime production in the vase solution and improves the effectiveness of 8-HQC. Van Doorn *et al*., (1991) [30] found that silver thiosulphate (656, 1312, and 2624 mg L^{-1} for 4 h) did not reduce the number of bacteria in petioles of Adiantum raddianum fronds. In contrast, $AgNO_3$ (12.5 and 25.0 mg L^{-1}) reduced the number of bacteria in the petiole to zero. For a long time, it was not clear why the effectiveness of $AgNO_3$ as a biocidal agent was highly variable. van Doorn *et al*. (1990) [29] noted that $AgNO_3$ cannot be used in water containing chlorine due to immediate precipitation of AgCl. Moreover, even in DI and distilled water, $AgNO_3$ will slowly undergo photochemical oxidation leading to a black Ag_2O deposit. $AgNO_3$ should be present in the vase solution in order to prolong vase life. Study on the mechanism of inhibitory action of Ag+ on microorganisms revealed that the expression of cellular proteins and enzymes that is necessary for ATP production, was inactivated with Ag+ (Yamanaka *et al*., 2005) [33]. In contrast, HQS probably acts principally by its chelating ability with metal ions, and thereby disruption of bacterial cell

enzyme function (Weinberg, 1957) [32]. However the using of Silver thiosulphate on cut flowers is of concern with regard to the disposal of waste silver solutions (Macnish *et al*., 2004) [15].

Materials and Methods

The investigations for the above said study were carried out in the Division of Horticulture, Sher-e-Kashmir University of Agricultural Science and Technology of Kashmir (SKUAST-K), Wadoora, Sopore during the year 2015-2016. Straight, good looking and healthy spikes of uniform size and length (about 80 cm) were selected from carnation flower var. Dark dona at paint brush stage. The harvested spikes were immediately kept in half filled bucket of water, to remove the field heat and to maintain turgidity of the spikes. Later on spikes were delivered in the cardboard boxes covered with polythene (to avoid desiccation) to the laboratory within half an hour of harvest. The spikes were placed in various pulsing solutions comprised of sucrose (5%- T_1), Silverthiosulphate (STS 0.5 mM- T_2), Lavender oil (100 ppm- T_3), Lavender oil (200 ppm- T_4), Lavender oil (100 ppm + STS 0.5 mM- T_5), Lavender oil (200 ppm + STS 0.5 mM-T_6), Rosemary oil (100 ppm- T_7), Rosemary oil (200 ppm- T_8), Rosemary oil (100 ppm + STS 0.5mM T_9), Rosemary oil (200 ppm + STS 0.5mM T_{10}), Sage oil (100 ppm T_{11}), Sage oil (200 ppm T_{12}), Sage oil (100 ppm + STS 0.5mM T_{13}), Sage oil (200 ppm + STS 0.5mM T_{114}), and control (distilled water- T_{15}). All the treatments were replicated thrice with three spikes as one sample unit. The volume of solution provided to each spike was 50 ml. The vases were kept in the laboratory at room temperature (20 ± 2°C) with 60 ± 5 % relative humidity under natural light. Various post-harvest parameters were estimated at every two day's interval as under:

- Water uptake (W_u) = $[C+S]_1 - [C+S]_2$
- Water loss (W_e) = $[C+S+F]_1 - [C+S+F]_2$
- Water balance (W_b) = W_U - WL
- Fresh Weight changes (F_w) = [C+S+F] - [C+S]
- Water uptake ratio/ water loss = WL / W_U
- Microbial = cfu ml^{-1}

Where, C = weight of container (g); S = weight of solution (g); F = weight of flower spike (g); Wu = water uptake (g/spike), Wl = water loss (g/spike), Wb = water balance (g/spike), Fw = fresh weight change (g/spike), 1= weight of container + solution on 1st day, 2 = weight of container + solution on 1st day, CFU = colony forming units

Vase life of the spike was recorded from the day of anthesis of the first flower bed to the senescence of last flower (Nowak and Mynett, 1985). Data obtained were analysed for critical difference among the various treatments under completely randomized design (Gomez and Gomez, 1984).

Results and Discussion

Water uptake

Generally the data in the table- revealed that there were significant differences among the means of water uptake recorded by the various pulsing treatments. Significantly highest cumulative water uptake 29.77 g $stem^{-1}$ was noticed in the carnation flowers treated with T_6 (Lavender oil 200 ppm + STS 0.5mM + Sucrose 5%), followed by T_4 (Lavender oil 100 ppm + STS 0.5mM + Sucrose 5%), T_5 (Lavender oil 200 ppm + Sucrose 5%), T_3 (Lavender oil 100ppm + Sucrose 5%), %), T_{14} (Sage oil 200 ppm + STS 0.5mM + Sucrose 5%), and T_{12} (Sage oil 100 ppm + STS 0.5mM + Sucrose 5%), recording 28.58, 27.88, 27.20, 26.32 and 26.05 g $stem^{-1}$, respectively. However significantly lowest cumulative water uptake (14.13 g $stem^{-1}$) was recorded in control. Same results were observed by Gowda (1994) [9], who observed that solutions of sucrose, STS alone are in combinatioin improved watrer uptake in gladiolus. This may be attributed to the fact that maintenance of higher water uptake in pulsing solution of sucrose plays an important role in absorbing more water by lowering the osmotic potential of flowering tissues. The vesicular blockage caused by various micro-organisms is inhibited by aluminium sulfate, siliver-thio sulfate which are well known germicides and are used for improving the shelf life of cut flowers. Halevy and Mayak, 1974; Khan *et al*. 2007, also attributed the higher water uptake in combined treatments of sucrose plus other biocides due to their additive role by clearing the path of water movement by inhibiting the vesicular blockage. Odak *et al*. (2015) [23] suggest that antimicrobial property of lavender oil is due to the presence of high level of monoterpenes. The major component was linalyl acetate (47.56%), linalool (28.06%), lavanduly 1 acetate (4.34%) and α- terpinol (3.75%) 1,8-cineol (1.14%), camphor (0.11%) and Borneol (0.85%) Verma et *al.* (2010) [31].

Water loss

On daily and cumulative, water loss of cut stems was highest from 2nd day to 10th day, in flowers treated with T_6 (Lavender oil 200 ppm + STS 0.5mM + Sucrose 5%), followed by T_4 (Lavender oil 100 ppm + STS 0.5mM + Sucrose 5%), T_5 (Lavender oil 200 ppm + Sucrose 5%), T_3 (Lavender oil 100ppm + Sucrose 5%), %), T_{14} (Sage oil 200 ppm + STS 0.5mM + Sucrose 5%), while as cut flowers treated by T_{15} (control) resulted in lowest water loss. In cumulative water loss the highest water loss was again recorded in T_6, followed by T_4, T_5, T_3 and T_{14}.Whereas, minimum cumulative water uptake was recorded in control. There were significant differences among the means of water loss recorded by the various pulsing treatments. The above results are supported by Gowda and Murthy,1992 [10] ; Murli *et al*, 1991; who found that water loss was significantly higher in Sucrose + STS treatments in case of cut gladiolus that may be attributed to the fact that the availability of more sugars could have increased the respiration rate thereby leading to more water loss through transpiration. Cut flowers show good transpirational loss when water moves unhindered through xylem vessels. Essential oils and sliver containing compounds (STS) helps in reducing the microbial growth in xylem vessels thus enhancing the uptake and subsequent transpirational loss through floral parts (Conner 1993) [6].

Water balance

Generally the data in the table- showed that, there were significant differences among the means of water balance recorded by the various pulsing treatments. Data depicts that the cumulative highest water balance (15.61 g $stem^{-1}$) was observed in flowers under T_6 (Lavender oil 200 ppm + STS 0.5Mm + Sucrose 5%), followed by T_4 (Lavender oil 100 ppm

+ STS 0.5Mm + Sucrose 5%) and T_5 (Lavender oil 200 ppm + Sucrose 5%), recording 14.82 and 14.32 g stem^{-1} respectively. However lowest cumulative water balance 4.69 g stem^{-1} was recorded in control. Halevy *et* al. 1978. Reported that Sucrose 5% results in better water balance of snapdragon cut flowers, when bacterial growth is eliminated. Sucrose plays an important role in improving the water balance of cut flowers by affecting the osmotic potential of cut flowers and water holding capacity of tissues, allowing less water to be transpired. Water balance is improved by lavender oil by inhibiting vascular blockage due to antimicrobial properties which in turn influences water uptake and transpirational loss and hence improved water balance in various flower spikes (Lau and Yang 1994, Bagamboula *et al*., 2004) [1]. Marousky (1971) [16] reported that the effect of sugars on the closure of stomatas causes reduction in water loss and improves water balance.

Fresh weight change

The perusal of data (Table-1.7) reveals that pulsing effect of postharvest chemicals and essential oil treatments have significantly effected fresh weight changes of cut carnation stems, except on 8th day and 10th day. Data recorded on fresh weight change after 20 h pulsing of cut carnation stems with T_6 (Lavender oil 200 ppm + STS 0.5Mm + Sucrose 5%) was highest, followed by T_5 (Lavender oil 200 ppm + Sucrose 5%), T_2 (STS 0.5Mm + Sucrose 5%), T_3 (Lavender oil 100 ppm + Sucrose 5%), T_{10} (Rosemary oil 200 ppm + STS 0.5Mm + Sucrose 5%), T_4 (Lavender oil 100 ppm + STS 0.5Mm + Sucrose 5%) and T_7 (Rosemary oil 100 ppm + Sucrose 5%). Whereas lowest fresh weight change 0.57 % was recorded significantly lowest by the stems in T_{15} (control). The fresh weight change of stems indicated a direct relationship with water potential of the transfer solution. The maintenance of higher fresh weight with sucrose and chemicals has also been reported in many cut flowers by various workers (Marousky, 1972., Mayak *et al*., 1973., Rao and Mohan Ram, 1992) [17, 3, 25]. Stimart (1983) [27] reported that, in Zinnia flowers there was initial increase in fresh weight followed by decrease. Many factors are responsible for decrease in fresh weight such as depletion of carbohydrates, oxidation of stem tannins, and vascular blockage by microorganisms.

Total vase life

The perusal of data (Table-1.10) depicted significant effect of pulsing on vase life of carnation cut flowers. Vase life was recorded maximum 12.89 days in flowers receiving treatment T_6 (Lavender oil 200ppm + STS 0.5Mm + Sucrose 5%), followed by T_4 (Lavender oil 100ppm + STS 0.5Mm + Sucrose 5%), T_5 (Lavender oil 200 ppm + Sucrose 5%), T_{10} (Rosemary oil 200ppm + STS 0.5Mm + Sucrose 5%), T_3 (Lavender oil 100 ppm + Sucrose 5%), T_{12} (Sage oil 100ppm + STS 0.5Mm + Sucrose 5%), T_{14} (Sage oil 200ppm + STS 0.5Mm + Sucrose 5%) and T_8 (Rosemary oil 100 ppm + STS 0.5Mm + Sucrose 5%), recording 12.95, 12.56, 12.34 and 12.00 days. Whereas, T_3, T_5, T_8, T_{10}, T_{12} and T_{14} are statistically at par among themselves. However, minimum vase life 10.00 days was recorded in control. Durkin 1979 reported that improvement in vase life of gladiolus spikes with citric acid was due to reduction in blockage of stem plugging, acidification of solution and improvement in water balance. The major cause of poor capability of many cut flowers (Bravdo *et al.*, 1974; Chandra *et al.*, 1981; van Doorn, 2004) [3, 4, 28], had been attributed to starvation in sugar pool, plugging of vesicular tissues by micro-organisms and damage by ethylene. However, the applied sugars might have compensated the requirement of lost sugars while as STS could have improved the water balance and protecting the flower from damaging effect of ethylene thereby maintaining an improved vase life of carnation flowers.

Water loss/Water uptake ratio

The perusal of data depicts that water loss/ water uptake ratio of cut carnation stems was increased gradually with passage of time. Pulsing of stems with Lavender oil, sucrose and STS resulted in lesser values of water loss/ water uptake ratio as compared with the individual treatments. Whereas, the maximum (1.84) water loss/ water uptake ratio was recorded in control (T_{15}). Data recorded on 12th day clearly indicated that among all the treatments T_6 maintained a better ratio (0.71) as compared to control (1.84). Antimicrobial activity of Lavender oil and sliver thiosulphate reduces microbial blockage of xylem vessels thus results in more uptake of water which inturn maintains turgidity in petals and guard cells of stomata resulting in complete closure of stomata and less water loss. The lowered water loss/ water uptake ratio in treated stems as compared to control was in close affirmity with the finding that water balance significantly increased by sucrose + metallic salts when compared to control in case of gladiolus (Reddy *et al*., 1996) [26].

Microbial count (cfu ml^{-1})

The study results reveal that the highest microbial count 5.78 cfu x 10^2 was recorded in control (T_{15}). Whereas, lowest microbial count 2.84 cfu x 10^2 was recorded in T_6 (Lavender oil 200 ppm + STS 0.5Mm + Sucrose 5%).Essential oils damages the cell wall and lipid membranes by disrupting proton motive force, ATP, Phosphate ion leakages across membranes, disrupting membrane permeability (Oliveira *et al*., 2007 Conner, 1993) [26, 13]. The present study revealed that among various chemical combinations T_6 was most effective against microbes in the vase solution. (Nermeen, T. Shanan. 2012) reported that lavender oil solutions were very effective as antimicrobial agents in inhibiting the growth of microorganisms and consequently, preventing the occlusion of xylem vessel

Table 1: Effect of pulsing with biocides and essential oils on water uptake (g stem^{-1}) in cut flowers of carnation cv. Dark Dona

Treatment		Water Uptake						Cumulative water uptake (g stem^{-1})
		2 days	4 days	6 days	8 days	10 days	12 days	
T_1	Sucrose (5%)	3.48	4.24	3.75	3.38	2.23	1.11	18.19
T_2	STS (0.5mM) + Sucrose (5%)	3.14	4.40	4.60	3.68	3.19	2.01	21.02
T_3	Lavender oil (100ppm) + Sucrose (5%)	3.62	5.61	5.70	5.21	4.03	3.03	27.20
T_4	Lavender oil (100 ppm) + STS (0.5mM) + Sucrose (5%)	4.00	5.81	5.92	5.42	4.28	3.28	28.71
T_5	Lavender oil (200 ppm) + Sucrose (5%)	3.82	5.64	5.83	5.32	4.15	3.12	27.88
T_6	Lavender oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	4.04	5.76	5.84	5.98	4.60	3.42	29.64
T_7	Rosemary oil (100ppm) + Sucrose (5%)	3.18	4.88	4.93	4.25	3.18	2.15	22.57
T_8	Rosemary oil (100 ppm) + STS (0.5mM) + Sucrose (5%)	3.32	5.18	5.24	4.45	3.40	2.40	23.99
T_9	Rosemary oil (200 ppm) + Sucrose (5%)	3.21	5.05	5.15	4.30	3.30	2.25	23.26
T_{10}	Rosemary oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	3.27	5.21	5.33	4.50	3.42	2.51	24.24
T_{11}	Sage oil (100ppm) + Sucrose (5%)	3.33	5.10	5.27	4.65	3.50	2.65	24.50
T_{12}	Sage oil (100 ppm) +STS (0.5mM) + Sucrose (5%)	3.42	5.31	5.48	5.09	3.85	2.90	26.05
T_{13}	Sage oil (200 ppm) + Sucrose (5%)	3.37	4.90	5.32	4.85	3.65	2.85	24.94
T_{14}	Sage oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	3.58	5.07	5.53	5.18	4.02	2.94	26.32
T_{15}	Control (water)	2.16	3.36	3.20	2.95	1.53	0.93	14.13
	CD ($p \leq 0.05$)	N.S	0.013	0.011	0.014	0.016	0.018	0.24

Table 2: Effect of pulsing with biocides and essential oils on water loss (g stem^{-1}) in cut flowers of carnation cv. "Dark Dona"

Treatment Detail		Water Loss						Cumulative water uptake (g stem^{-1})
		2 days	4 days	6 days	8 days	10 days	12 days	
T_1	Sucrose (5%)	1.08	1.62	1.90	1.83	1.80	1.76	9.99
T_2	STS (0.5mM) + Sucrose (5%)	1.20	1.80	1.92	1.90	2.13	1.81	10.76
T_3	Lavender oil (100ppm) + Sucrose (5%)	1.45	2.01	2.31	2.58	2.75	2.15	13.25
T_4	Lavender oil (100 ppm) + STS (0.5mM) + Sucrose (5%)	1.48	2.08	2.40	2.63	2.98	2.32	13.89
T_5	Lavender oil (200 ppm) + Sucrose (5%)	1.45	2.02	2.38	2.60	2.83	2.28	13.56
T_6	Lavender oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	1.51	2.10	2.42	2.65	3.04	2.44	14.16
T_7	Rosemary oil (100ppm) + Sucrose (5%)	1.21	1.90	2.10	2.12	2.18	1.85	11.36
T_8	Rosemary oil (100 ppm) + STS (0.5mM) + Sucrose (5%)	1.31	1.96	2.21	2.18	2.26	1.97	11.89
T_9	Rosemary oil (200 ppm) + Sucrose (5%)	1.22	1.86	2.15	2.16	2.23	1.93	11.55
T_{10}	Rosemary oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	1.42	2.05	2.19	2.28	2.31	1.99	12.24
T_{11}	Sage oil (100ppm) + Sucrose (5%)	1.30	1.99	2.25	2.31	2.40	2.01	12.26
T_{12}	Sage oil (100 ppm) +STS (0.5mM) + Sucrose (5%)	1.37	1.94	2.30	2.52	2.62	2.09	12.84
T_{13}	Sage oil (200 ppm) + Sucrose (5%)	1.35	1.84	2.27	2.42	2.51	2.06	12.45
T_{14}	Sage oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	1.40	1.89	2.36	2.54	2.71	2.12	13.02
T_{15}	Control (water)	1.02	1.58	1.70	1.76	1.67	1.71	9.44
	CD ($p \leq 0.05$)	0.012	0.013	0.010	0.011	0.008	N.S	0.19

Table 3: Effect of pulsing with biocides and essential oils on water uptake ratio in cut flowers of carnation cv. "Dark Dona"

Treatment Detail		Water Uptake ratio					
		2 days	4 days	6 days	8 days	10 days	12 days
T_1	Sucrose (5%)	0.31	0.33	0.50	0.54	0.80	1.59
T_2	STS (0.5mM) + Sucrose (5%)	0.38	0.41	0.42	0.52	0.67	0.90
T_3	Lavender oil (100ppm) + Sucrose (5%)	0.40	0.36	0.41	0.50	0.68	0.71
T_4	Lavender oil (100 ppm) + STS (0.5mM) + Sucrose (5%)	0.37	0.36	0.41	0.49	0.70	0.71
T_5	Lavender oil (200 ppm) + Sucrose (5%)	0.38	0.36	0.41	0.49	0.68	0.73
T_6	Lavender oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	0.34	0.36	0.41	0.44	0.66	0.71
T_7	Rosemary oil (100ppm) + Sucrose (5%)	0.38	0.39	0.43	0.50	0.69	0.86
T_8	Rosemary oil (100 ppm) + STS (0.5mM) + Sucrose (5%)	0.39	0.38	0.42	0.49	0.66	0.82
T_9	Rosemary oil (200 ppm) + Sucrose (5%)	0.38	0.37	0.42	0.50	0.68	0.86
T_{10}	Rosemary oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	0.43	0.39	0.41	0.51	0.68	0.79
T_{11}	Sage oil (100ppm) + Sucrose (5%)	0.39	0.39	0.43	0.50	0.69	0.76
T_{12}	Sage oil (100 ppm) +STS (0.5mM) + Sucrose (5%)	0.40	0.37	0.42	0.50	0.68	0.72
T_{13}	Sage oil (200 ppm) + Sucrose (5%)	0.40	0.38	0.43	0.50	0.69	0.72
T_{14}	Sage oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	0.39	0.37	0.43	0.49	0.67	0.72
T_{15}	Control (water)	0.47	0.47	0.49	0.48	1.09	1.84
	CD ($p \leq 0.05$)	N.S	N.S	0.009	0.008	0.011	0.014

Table 4: Effect of pulsing with biocides and essential oils on water balance (g stem^{-1}) in cut flowers of carnation cv. "Dark Dona"

Treatment Detail		Water balance						Cumulative water uptake (g stem^{-1})
		2 days	4 days	6 days	8 days	10 days	12 days	
T_1	Sucrose (5%)	2.40	2.84	1.85	1.55	1.43	-0.65	8.20
T_2	STS (0.5mM) + Sucrose (5%)	1.94	2.60	2.68	1.78	1.06	0.20	10.26
T_3	Lavender oil (100ppm) + Sucrose (5%)	2.17	3.60	3.39	2.63	1.28	0.88	13.95
T_4	Lavender oil (100 ppm) + STS (0.5mM) + Sucrose (5%)	2.52	3.73	3.52	2.79	1.30	0.96	14.82
T_5	Lavender oil (200 ppm) + Sucrose (5%)	2.37	3.62	3.45	2.72	1.32	0.84	14.32
T_6	Lavender oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	2.53	3.66	3.42	3.33	1.56	0.98	15.48
T_7	Rosemary oil (100ppm) + Sucrose (5%)	1.97	2.98	2.83	2.13	1.00	0.30	11.21
T_8	Rosemary oil (100 ppm) + STS (0.5mM) + Sucrose (5%)	2.01	3.22	3.03	2.27	1.14	0.43	12.10
T_9	Rosemary oil (200 ppm) + Sucrose (5%)	1.99	3.19	3.00	2.14	1.07	0.32	11.71
T_{10}	Rosemary oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	1.85	3.16	3.14	2.22	1.11	0.52	12.00
T_{11}	Sage oil (100ppm) + Sucrose (5%)	2.03	3.11	3.02	2.34	1.10	0.64	12.24
T_{12}	Sage oil (100 ppm) +STS (0.5mM) + Sucrose (5%)	2.05	3.37	3.18	2.57	1.23	0.81	13.21
T_{13}	Sage oil (200 ppm) + Sucrose (5%)	2.02	3.06	3.05	2.43	1.14	0.79	12.49
T_{14}	Sage oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	2.18	3.18	3.17	2.64	1.31	0.82	13.30
T_{15}	Control (water)	1.14	1.78	1.50	1.19	-0.14	-0.78	4.69
	CD ($p \leq 0.05$)	0.013	N.S	0.010	0.016	0.009	N.S	0.20

Table 5: Effect of pulsing with biocides and essential oils on Fresh weight changes (%) in cut flowers of carnation cv. "Dark Dona"

Treatment Detail		Fresh weight changes					
		2 days	4 days	6 days	8 days	10 days	12 days
T_1	Sucrose (5%)	1.98	2.71	4.30	4.01	-3.97	-11.24
T_2	STS (0.5mM) + Sucrose (5%)	2.50	5.38	6.19	-0.75	-5.00	-7.62
T_3	Lavender oil (100ppm) + Sucrose (5%)	2.43	4.98	8.38	5.20	3.51	0.34
T_4	Lavender oil (100 ppm) + STS (0.5mM) + Sucrose (5%)	2.28	5.08	8.22	6.95	4.41	0.86
T_5	Lavender oil (200 ppm) + Sucrose (5%)	2.77	4.76	6.92	6.20	4.92	-0.99
T_6	Lavender oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	2.81	6.47	9.85	14.91	9.89	1.83
T_7	Rosemary oil (100ppm) + Sucrose (5%)	2.02	3.43	5.96	4.94	2.53	0.67
T_8	Rosemary oil (100 ppm) + STS (0.5mM) + Sucrose (5%)	1.61	3.46	4.50	1.38	0.57	-2.42
T_9	Rosemary oil (200 ppm) + Sucrose (5%)	1.49	3.36	5.79	4.46	1.04	-3.97
T_{10}	Rosemary oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	2.37	4.14	6.40	1.93	0.99	-6.45
T_{11}	Sage oil (100ppm) + Sucrose (5%)	1.19	2.25	3.32	1.42	-3.10	-5.93
T_{12}	Sage oil (100 ppm) +STS (0.5mM) + Sucrose (5%)	1.45	2.80	4.96	1.24	-0.80	-3.23
T_{13}	Sage oil (200 ppm) + Sucrose (5%)	1.36	2.91	4.47	2.64	0.27	-7.11
T_{14}	Sage oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	1.95	3.32	5.33	1.58	-0.94	-5.69
T_{15}	Control (water)	0.57	1.60	2.46	-1.71	-1.71	-15.37
	CD ($p \leq 0.05$)	0.014	0.013	0.016	N.S	N.S	0.039

Table 6: Effect of pulsing with biocides and essential oils on Microbial count in vase solution (cfu ml^{-1}) x 10^2

Treatment Detail		Microbial count (cfu ml^{-1}) x 10^2					
		2 days	4 days	6 days	8 days	10 days	12 days
T_1	Sucrose (5%)	0.75	1.46	1.90	2.54	3.92	4.34
T_2	STS (0.5mM) + Sucrose (5%)	0.72	1.37	1.51	2.46	3.74	4.21
T_3	Lavender oil (100ppm) + Sucrose (5%)	0.64	1.19	1.26	2.19	3.14	3.37
T_4	Lavender oil (100 ppm) + STS (0.5mM) + Sucrose (5%)	0.40	1.13	1.22	2.07	2.80	2.95
T_5	Lavender oil (200 ppm) + Sucrose (5%)	0.62	1.16	1.29	2.22	3.08	3.17
T_6	Lavender oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	0.35	1.11	1.19	1.91	2.49	2.84
T_7	Rosemary oil (100ppm) + Sucrose (5%)	0.67	1.24	1.36	2.30	3.30	3.54
T_8	Rosemary oil (100 ppm) + STS (0.5mM) + Sucrose (5%)	0.64	1.17	1.33	2.24	3.28	3.69
T_9	Rosemary oil (200 ppm) + Sucrose (5%)	0.69	1.20	1.35	2.32	3.32	3.77
T_{10}	Rosemary oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	0.64	1.15	1.31	2.27	3.24	3.64
T_{11}	Sage oil (100ppm) + Sucrose (5%)	0.60	1.21	1.87	2.29	3.31	3.67
T_{12}	Sage oil (100 ppm) +STS (0.5mM) + Sucrose (5%)	0.48	1.19	1.22	2.22	3.20	3.43
T_{13}	Sage oil (200 ppm) + Sucrose (5%)	0.46	1.13	1.26	2.26	3.28	3.60
T_{14}	Sage oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	0.43	1.17	1.30	2.24	3.24	3.40
T_{15}	Control (water)	1.12	3.22	3.48	3.95	4.18	5.78
	CD ($p \leq 0.05$)	N.S	0.032	0.029	0.019	0.020	0.017

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