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Effect of essential oils and silver based biocides on the vase life of cut carnation (*Dianthus caryophyllus* cv. dark-dona)

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Abstract
This study was conducted to investigated the effect of some Essential oil (Lavender, Rosemary, Sage oil), Sucrose and Silver thiosulphate in combination or alone for extending the vase life of cut carnation. Stem of cut carnation were kept in solution containing essential oil of Lavender, Rosemary and Sage (100 & 200 ppm), STS (0.5mM) and sucrose (5%) and control. Data showed that solution containing Lavender oil 200 ppm +STS 0.5Mm + sucrose 5% could increase the flower longevity than control and maintained better water relations i.e. Total solution absorbed by stem, fresh weight and vase life. Totally our results suggest that the application of Lavender oil 200 ppm +STS 0.5Mm + sucrose 5% is proved to be best preservative solution for cut carnation flowers.

Keywords: Vase life, cut carnation flowers, essential oils, preservation solution

Introduction
Carnation (*Dianthus caryophyllus* L.), a member of family Caryophyllaceae 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. Carnation was traditionally prescribed in European herbal medicine to treat coronary and nervous disorders (Mc George & Hammett 2002) [10] and fevers (Bown, 1995) [1].

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) [9]. Deficiency of potassium causes reduction in water uptake and tolerance to ethylene. Flowers of K-deficient plants show shorter vase-life (Halevy, 1976) [7]. 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) [8]. 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.

Van Doorn *et al*., (1991) [17] 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) [16] noted that $AgNO_3$ cannot be used in water containing chlorine due to immediate precipitation of AgCl. $AgNO_3$ 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) [18]. 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).

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

- Total solution absorbed by stem
- Fresh Weight (F_w) = [C+S+F] - [C+S]
- Vase life
- Days to be initiation of outer petal senescence

Where, C = weight of container (g); S = weight of solution (g); F = weight of flower spike (g);

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) [12]. Data obtained were analysed for critical difference among the various treatments under completely randomized design (Gomez and Gomez, 1984) [6].

Results and Discussion

Total solution absorbed by stem (ml stem^{-1})

The data presented in (Table-1) reveals that the solution absorbed by stem was increased regularly from 2nd day to 8th day and decreased onwards. Significantly highest cumulative solution absorbed by stem 25.72 ml 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%) and T_3 (Lavender oil 100 ppm + Sucrose 5%), recording 22.66, 21.87, and 21.64 ml stem^{-1} respectively. However significantly overall lowest cumulative solution absorbed by stem (12.07ml stem^{-1}) was recorded in control.

Solution absorbed by stems is impaired by microbial occlusion of xylem vessels of cut flowers and it is well established fact that essential oils show antimicrobial property. Essential oils exhibit inhibitory effect on uptake of oxygen and oxidative phosphorylation of pathogens, which causes disturbance in cytoplasmic membrane, disrupting proton motive force, active coagulation of cell contents and thus causes energy depletion which in turn improves water uptake (Oliveira *et al*., 2007 Conner, 1993) [14, 5].

Fresh weight (g stem^{-1})

The Data presented in (Table. 2) reveals that the fresh weight regularly increased from 2nd day to 8th day and decreased onwards. The highest fresh weight (21.72 g stem^{-1}) was recorded in T_6 (Lavender oil 200 ppm + STS 0.5Mm + Sucrose 5%), followed by T_4 (Lavender oil 200 ppm + STS 0.5Mm + Sucrose 5%), recording 20.15 g stem^{-1} respectively. Whereas, lowest fresh weight (14.96 g stem^{-1}) was recorded significantly lowest by the stems in T_{13} (Sage oil 200 ppm + Sucrose 5%). Whereas, from day 8 onwards fresh weight was decreased in all treatments.

Due to various combinations of essential oils, cell wall and cell membrane of microbes is damaged and ion leakage and permeability are increased and the damaged cells undergo death by essential oils (Burt, 2004) [3] which probably helps in increasing water uptake, improved water balance which in turn helps in increasing fresh weight.

Days to be initiation of outer petal senescence

The perusal of data (Table. 3) depicted significant effect of pulsing on initiation of outer petal senescence in carnation cut flowers. Initiation of outer petal senescence was delayed to (8.50) days in cut flowers which received treatment 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_{10} (Rosemary oil 200 ppm + STS 0.5Mm + Sucrose 5%), T_{14} (Sage oil 200ppm + STS 0.5Mm + Sucrose 5%), T_8 (Rosemary oil 100 ppm + STS 0.5Mm + Sucrose 5%), T_{12} (Sage oil 100 ppm + STS 0.5Mm + Sucrose 5%), T_7 (Rosemary oil 100 ppm + Sucrose 5%), T_9 (Rosemary oil 200 ppm + Sucrose 5%), T_{11} (Sage oil 100 ppm + Sucrose 5%) and T_3 (Lavender oil 100 ppm + Sucrose 5%), recording 8.38, 8.30, 8.25, 8.24, 8.15, 8.13, 8.11, 8.03, 8.02 and 8.00 days. However, T_4, T_{10}, T_{14}, T_{12} T_7 and T_5 are statistically at par among themselves. Whereas, Initiation of outer petal senescence 6.25 days was first noticed in control.

The main factor for early senescence is ethylene because it leads to climatric rise in respiration and transpiration rate. Cut flowers are generally treated with anionic complex Sliver thiosulphate, as inhibitor of ethylene, for increase longevity of cut flowers. Because it is determined that STS could reduce the abscission of flowers when they subjected to ethylene. In addition, it is reported that STS provides some antimicrobial activity inside the plant tissues (Nowak and Rudnicki, 1990) [13]. Addition of Sliver thiosulphate to the pulsing solution increased the concentrations of glucose and fructose in florets this data suggested that Sliver thiosulphate may improve sucrose uptake and its subsequent hydrolysis (Meir *et al*., 1995) [11].

Vase life

The perusal of data (Table. 4) 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) [2, 8, 15] 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.

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

Treatment Detail		Fresh weight					
		2 days	4 days	6 days	8 days	10 days	12 days
T_1	Sucrose (5%)	15.43	15.54	15.78	15.75	14.53	13.43
T_2	STS (0.5mM) + Sucrose (5%)	16.40	16.86	16.09	15.88	15.12	14.78
T_3	Lavender oil (100ppm) + Sucrose (5%)	18.09	18.54	19.14	18.58	18.28	17.72
T_4	Lavender oil (100 ppm) + STS (0.5mM) + Sucrose (5%)	20.15	20.7	21.32	21.07	20.57	19.87
T_5	Lavender oil (200 ppm) + Sucrose (5%)	18.56	18.92	19.31	19.18	18.95	17.88
T_6	Lavender oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	21.93	22.71	23.43	24.51	23.44	21.72
T_7	Rosemary oil (100ppm) + Sucrose (5%)	18.16	18.41	18.86	18.68	18.25	17.92
T_8	Rosemary oil (100 ppm) + STS (0.5mM) + Sucrose (5%)	17.62	17.94	18.12	17.58	17.44	16.92
T_9	Rosemary oil (200 ppm) + Sucrose (5%)	18.40	18.74	19.18	18.94	18.32	17.41
T_{10}	Rosemary oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	18.56	18.88	19.29	18.48	18.31	16.96
T_{11}	Sage oil (100ppm) + Sucrose (5%)	17.06	17.24	17.42	17.10	16.33	15.86
T_{12}	Sage oil (100 ppm) +STS (0.5mM) + Sucrose (5%)	18.83	19.08	19.48	18.79	18.41	17.96
T_{13}	Sage oil (200 ppm) + Sucrose (5%)	14.96	15.19	15.42	15.15	14.80	13.71
T_{14}	Sage oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	19.33	19.59	19.97	19.26	18.78	17.88
T_{15}	Control (water)	17.60	17.78	17.93	17.20	17.12	14.81
	CD ($p \leq 0.05$)	0.010	0.011	0.023	0.019	0.018	0.013

Table 2: Effect of pulsing with biocides and essential oils on days taken to initiation of outer petal senescence in cut flowers of carnation cv. "Dark Dona"

Treatment		Days to initiation of outer petal senescence (days)
T_1	Sucrose (5%)	7.27
T_2	STS (0.5mM) + Sucrose (5%)	7.78
T_3	Lavender oil (100ppm) + Sucrose (5%)	8.00
T_4	Lavender oil (100 ppm) + STS (0.5mM) + Sucrose (5%)	8.38
T_5	Lavender oil (200 ppm) + Sucrose (5%)	8.11
T_6	Lavender oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	8.50
T_7	Rosemary oil (100ppm) + Sucrose (5%)	8.13
T_8	Rosemary oil (100 ppm) + STS (0.5mM) + Sucrose (5%)	8.24
T_9	Rosemary oil (200 ppm) + Sucrose (5%)	8.03
T_{10}	Rosemary oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	8.30
T_{11}	Sage oil (100ppm) + Sucrose (5%)	8.02
T_{12}	Sage oil (100 ppm) +STS (0.5mM) + Sucrose (5%)	8.15
T_{13}	Sage oil (200 ppm) + Sucrose (5%)	7.99
T_{14}	Sage oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	8.25
T_{15}	Control (water)	6.25
	CD ($p \leq 0.05$)	0.16

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

Treatment		Days to initiation of outer petal senescence (days)
T_1	Sucrose (5%)	11.18
T_2	STS (0.5mM) + Sucrose (5%)	11.52
T_3	Lavender oil (100ppm) + Sucrose (5%)	12.22
T_4	Lavender oil (100 ppm) + STS (0.5mM) + Sucrose (5%)	12.68
T_5	Lavender oil (200 ppm) + Sucrose (5%)	12.41
T_6	Lavender oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	12.89
T_7	Rosemary oil (100ppm) + Sucrose (5%)	11.81
T_8	Rosemary oil (100 ppm) + STS (0.5mM) + Sucrose (5%)	12.00
T_9	Rosemary oil (200 ppm) + Sucrose (5%)	11.64
T_{10}	Rosemary oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	12.30
T_{11}	Sage oil (100ppm) + Sucrose (5%)	11.79
T_{12}	Sage oil (100 ppm) +STS (0.5mM) + Sucrose (5%)	12.10
T_{13}	Sage oil (200 ppm) + Sucrose (5%)	11.98
T_{14}	Sage oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	12.22
T_{15}	Control (water)	10.00
	CD ($p \leq 0.05$)	0.18

*vase life indicates the duration for which aesthetic value of flowers has not deteriorated.

Table 4: Effect of pulsing with biocides and essential oils on total solution (ml stem^{-1}) absorbed by cut flowers of carnation cv. "Dark Dona"

Treatment Detail		Solution absorbed by stem						Cumulative solution absorbed by stem(ml)
		2 days	4 days	6 days	8 days	10 days	12 days	
T_1	Sucrose (5%)	2.18	4.24	4.12	2.68	1.82	0.75	15.79
T_2	STS (0.5mM) + Sucrose (5%)	2.52	3.38	4.46	3.76	1.98	0.88	16.98
T_3	Lavender oil (100ppm) + Sucrose (5%)	2.64	4.68	5.72	5.21	2.29	1.10	21.64
T_4	Lavender oil (100 ppm) + STS (0.5mM) + Sucrose (5%)	3.15	4.76	5.81	5.34	2.39	1.21	22.66
T_5	Lavender oil (200 ppm) + Sucrose (5%)	2.69	4.71	5.76	5.25	2.32	1.14	21.87
T_6	Lavender oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	3.29	4.92	6.10	5.98	3.22	2.21	25.72
T_7	Rosemary oil (100ppm) + Sucrose (5%)	2.54	3.73	4.79	3.80	2.02	1.03	17.91
T_8	Rosemary oil (100 ppm) + STS (0.5mM) + Sucrose (5%)	2.57	3.98	5.24	4.10	2.10	1.08	19.07
T_9	Rosemary oil (200 ppm) + Sucrose (5%)	2.52	3.60	4.64	3.88	1.98	0.93	17.55
T_{10}	Rosemary oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	2.61	4.09	5.38	4.16	2.19	1.18	19.61
T_{11}	Sage oil (100ppm) + Sucrose (5%)	2.49	3.68	4.91	4.22	2.14	1.06	18.50
T_{12}	Sage oil (100 ppm) +STS (0.5mM) + Sucrose (5%)	2.66	4.12	5.29	4.78	2.26	1.12	20.23
T_{13}	Sage oil (200 ppm) + Sucrose (5%)	2.46	3.54	4.83	4.11	2.06	1.03	18.03
T_{14}	Sage oil (200 ppm) + STS (0.5mM) + Sucrose (5%)	2.59	4.00	5.14	4.71	2.19	1.10	19.73
T_{15}	Control (water)	1.98	2.64	3.00	2.34	1.72	0.39	12.07
	CD ($p \leq 0.05$)	N.S	N.S	0.016	0.023	0.009	0.022	0.31

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