International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(5): 3352-3356

Received: 01-07-2019
Accepted: 03-08-2019

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Post harvest treatment for extending the vase life of Lilium cv. Pollayanna

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Abstract
An investigation was undertaken on the effect of certain preservatives *viz.*, sucrose, 8–HQ and Nanosilver on the physical changes of cut Lilium flowers during vase life period. The result of the investigation proved that the use of these preservatives in combination is a must to improve the quality, flower opening and vase life. Further, the use of sucrose, 8 – HQ and Nanosilver (NS) in the vase solution significantly reduced the number of microbial colonies with the passing of time, there by the water conductance through the xylem vessels increased. Among all the treatments imposed, treatment of NS 75 ppm + 8 – HQ 150 ppm + sucrose 2 per cent was found to be the best by registering relative fresh weight (87080%), dry matter (52.93%), leaf water content (0.405 g g DW^{-1}), vase solution uptake (11.52 g $stem^{-1}$ day^{-1}), daily water loss (5.87 g $stem^{-1}$ day^{-1}), water balance (92.13 g $stem^{-1}$ day^{-1}), days taken for bud opening (3.40 days), longest vase life (17.68 days), freshness (92.64%) and colour retention index (98.32%).

Keywords: Lilium, cut flowers, post harvest, nano silver, sucrose, vase life

Introduction
Among various cut flowers, lilium has just opened its way in floriculture industry of our country due to its immense potential as cut flower. Lilium ranks 6th among the top ten cut flowers of the world. Large volume of cut flowers *i.e.*, around 28-32% are lost annually due to poor post harvest handling measures because of its perishable nature (Dadlani, 1997) [3]. Keeping quality of flower is decided by its hereditary factor. However, it can be manipulated to certain extent by using novel preservative treatments. Keeping of cut flowers in various preservatives has effectively been used form long time to improve their longevity (Khan *et al*., 2007) [15].
Nanosilver particles (NS) has been widely used as a preservative due to its anti bacterial property. It also has the additional benefit of high durability, simple and easy to use and lack of side effect than other anti-bacterial agents (Van Doorm, 1997) [30]. With the above background the present study has been investigated on the effects of NS solution treatments on extending vase life of cut lilium flowers.
However, the diminishing keeping quality of cut lilium badly affects the growers as well as the traders. Lower status of water, carbohydrates, proteins and fats in the floral tissue, poor handling and marketing methods badly impair the physiology and biochemistry of flower petal leading to shortened vase life of cut flowers. Keeping this in view, the present investigation was also aimed towards discerning the events leading to senescence of cut lilium by supplying, 8-HQ and sucrose through the vase solution at different concentrations.

Materials and Methods
Lilium flowers were procured from the M/s. Balaji Flowers, Devashola Estate, The Nilgiris during spring season. Thereafter, they were kept under precooling (7 ^{o}C) and then transported with in 3h to the Tamil Nadu Agricultural University. To minimize moisture loss, flowers were covered with plastic film during transportation. At the laboratory, stem ends were re-cut by ≥ 10 cm, and stems with about 50 cm length were used in experiment. The aqueous test solutions were: H_1 –Nanosilver (NS) 50 ppm, H_2 –NS 75 ppm, H_3 – 8-HQ 150 ppm, H_4 – 8-HQ 200ppm, H_5 – H_1 + 2% Sucrose, H_6 – H_2 + 2% Sucrose, H_7 – H_3 + 2% Sucrose, H_8 – H_4 + 2% Sucrose, H_9 – H_3 + H_5, H_{10} – H_3 + H_6, H_{11} – H_4 + H_5, H_{12} – H_4 + H_6, H_{13} – Sucrose 2% and H_{14} – Control (Distilled water). The experiment was conducted in a completely randomized design with factorial concept and replicated thrice with holding method of treatment. The observations recorded by adopting the following methods.

Relative Fresh weight (RFW)
The difference between the weight of the container and vase solution (with flower) and the weight of container and the vase solutions (without flower) were recorded at every alternate day interval to measure the fresh weight change of flower during that particular duration of period (He *et al*., 2006) [10]. The weight of flower stalk on the first day of each experiment was assumed to be 100 per cent. Subsequent weights were referred to as percentage of the initial value.

$$RFW\ (\%) = \frac{\text{Fresh weight of stem in mentioned day}}{\text{Fresh weight of stem in day zero}} \times 100$$

Dry matter
Each stem placed in oven at 105 ºC for 48 hrs and final dry matter was recorded and expressed as %.

$$DM = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

Leaf water content (g)
Water content was calculated as (Fresh weight – Dry weight)/Dry weight (Jones *et al*., 1993). Water content was determined on days 0,1,4,7 and 10 for three replicate detached leaflets from different stem.

Vase solution uptake
The difference between consecutive measurements of the container and the vase solution (without flower) were recorded at three day interval to measure the water uptake within that particular duration of vase period and presented as g per stem per day (He *et al*., 2006) [10].

Vase solution uptake rate (g stem^{-1} day^{-1}) = ($S_{t-1} - S_t$)

Where,
S_{t-1} = Weight of vase solution (g) on the previous day
S_t = Weight of vase solution (g) at t = day 1,4,7, etc.,

Daily water loss
The difference between consecutive measurements of the container and the vase solutions (with flower) were recorded at every alternate day interval to measure the transpirational loss of water within that particular duration of vase period and presented as g per stem per day (He *et al*., 2006) [10].

Daily water loss (g stem^{-1} day^{-1}) = ($C_{t-1} - C_t$)

Where,
C_{t-1} = Combined weights of the stem and vase (g) on the previous day
C_t = Combined weights of the stem and vase (g) at t = day 1,2,3, etc.,

Water balance
Water balance in the cut flowers was calculated as the difference between water uptake and transpirational loss of water and presented as g per flower (He *et al*., 2006) [10].

WB (g stem^{-1} day^{-1}) = W_0 - W_1

Where,
W_0 = Vase solution uptake
W_1 = Daily water loss

Days taken for bud opening
The number of days taken for flower bud opening was observed and expressed in days.

Vase life of flowers
The vase life of cut flower was recorded as per the method suggested by Nowak and Mynett (1985) [13]. The vase life of cut spike was recorded from the day of anthesis of the first flower bud to the senescence of last flower bud.

Freshness index (FI)
The number of flowers which retained freshness without exhibiting petal necrosis, wilting and browning was measured by visual observation using the following score expressed as per cent fresh flowers or freshness index.

Freshness index (FI)

Condition of flowers	Score	Number of flower buds under this score
Freshness – Very high	5	X_1
Freshness – High	4	X_2
Freshness – Medium	3	X_3
Freshness – Low	2	X_4
Freshness – Very low	1	X_5

Freshness index (FI) was computed using the following formula,

$$FI = \frac{(5 \times X_1) + (4 \times X_2) + (3 \times X_3) + (2 \times X_4) + (1 \times X_5)}{(X_1 + X_2 + X_3 + X_4 + X_5) \times 5} \times 100$$

Colour rétention index
The retention of colour of *Lilium spp.* flowers was recorded by the following score,

Colour rétention index

Flower colour development during storage	Score	Number of flower buds under this score
Bright	5	X_1
Partially bright	4	X_2
Starts fading	3	X_3
Partially faded	2	X_4
Fully faded	1	X_5

Colour retention index (CRI) was computed by using the following formula

$$CRI = \frac{(5 \times X_1) + (4 \times X_2) + (3 \times X_3) + (2 \times X_4) + (1 \times X_5)}{(X_1 + X_2 + X_3 + X_4 + X_5) \times 5} \times 100$$

Results and Discussion
Holding solution refers to the solution which is used to hold the cut stems. Adding appropriate agents to the holding solution would effectively help to extend the vase life of flower. Holding is a practice is quite often useful for the wholesale buyers and retailers involved in flower trade to keep the flowers in a fresh condition for a long time.
Sucrose is widely used in floral preservatives and it acts as a food source or respiratory substrate and delays the degradation of proteins and improves the water balance of cut flowers. Steinitz (1982) [28] opined that addition of sucrose to the holding solution increases the mechanical rigidity of the stem by inducing cell wall thickening and lignifications of vascular tissues. Sucrose alone, however, tends to promote microbial growth. Hence, the combination of acidifying agent

and biocide or growth regulator is generally used to extend the vase life of cut flowers. 8-HQ plays a vital role in checking microbial growth in the holding solution. They reported a decrease in the respiration rate of cytokinin treated flowers and proposed that cytokinins increase flower longevity as a result of reduced respiration, increased water uptake and delayed petal senescence.

Nano silver (NS) is a novel antibacterial compound that can kill 650 species of bacteria in water (Nell, 1992; Furno *et al*., 2004) [22, 6]. NS is thought to release monovalent silver ions (Ag^+) which replace the hydrogen cation (H^+) of sulfhydryl or thiol groups (-SH) on surface proteins in bacterial cell membranes, thereby decreasing membrane permeability and eventually causing cell death (Feng *et al*., 2000) [5]. NS is currently used as an antimicrobial in various fields, including the medical industry, silver embedded fabrics, water purification and vegetable disinfection (Davies and Etris, 1997; Klaus *et al*., 1999; Jiang *et al*., 2004) [4, 16, 12].

Since the holding solution treatment is relatively for a long period of time, the concentrations of sugar (sucrose), Nanoparticles (Nanosilver) and biocide (8 - hydroxyl quinoline) are generally reduced to half of those used for pulsing treatment. The results of the experiment on optimization of holding solution for lilium are discussed here under.

Water relations namely water uptake, transpirational loss of water, water balance are the most important factors influencing the quality and longevity of cut flowers (Roger, 1973 and Mayak *et al*., 1974) [25, 20]. Aarts (1957) [1] reported that uninterrupted water supply is the major requirement for increased vase life. Relative fresh weight of stem was the highest in treatment H_{10} (NSP 75 ppm + 8 – HQ 150 ppm + sucrose 2 per cent). The variation in fresh weight might be due to the differences in solution uptake, transpirational loss of water and the water balance in the stem which are interlinked.

The fresh weight of the flower stalk indicates that water and carbohydrate levels are essential in maintaining the flower quality as reported by Singh *et al*. (2003) [21] in carnation. The decrease in fresh weight in control (distilled water) might be due to reduced levels of starch, cell wall polysaccharides, proteins and nucleic acid degrading enzymes. Ethylene induces rapid hydrolysis of storage materials due to which increased weight loss and senescence occur in the flower (Tiwari and Singh, 2000) [29].

The maximum leaf water content (LWC) was observed in the treatment H_{10} (NSP 75 ppm + 8 – HQ 150 ppm + sucrose 2 per cent), while the treatment H_{14} (Control) exhibited the minimum values. Higher leaf water content observed throughout the vase period as the vase life of cut flowers are deprived of its natural source of food, water, minerals and hormones and carry out their life processes at the expense of the reserved food. Further improvement of LWC by addition of other preservatives may be due to their effects on preventing microbial growth and cleaning the path of water due to xylem blockage. Similar results have also been reported by Marousky (1971) [18].

The uptake of vase solution on day 1, 4, 7, 10, 12 and cumulative water uptake were higher in treatment H_{10}. High amount of ethylene producing enzymes and ethylene are responsible for water loss. The increased water uptake might also be due to translocation of sucrose which accumulates in flowers and increases the osmotic potential which improved the ability of the stalk to absorb water. This is in confirmation with the results of Halevy (1976) [9] and Reddy and Singh (1994) [24] in tuberose. The increase in water uptake has direct relationship with the fresh weight of flowers which explains the higher gain in fresh weight in the treatment H_{10}. The maximum holding solution absorption was obtained using preservative solutions containing 20 mg L^{-1} $AgNO_3$ plus 4% or 6% sucrose by Nair *et al*. (2003) [21] in gerbera flowers.

The daily water loss was the lowest in treatment H_{10} which might be due to the fact that sucrose helps in increasing water uptake and decreased the transpirational loss of water by decreasing stomatal opening thereby maintaining turgidity of flowers. This is accordance with the findings of Marousky (1968) [19] and Bravdo *et al*. (1974) [2].

The water balance was maximum in treatment H_{10} which might be due to the fact that sucrose in the lower concentration acts as a food source or respiratory substrate and delays the degradation of protein and improves water balance. The increased water uptake and maintenance of normal levels of transpirational loss of weight (TLW) improved the positive water balance and thereby contributed to the increased fresh weight for longer period which ultimately prolonged the vase life. The rate of transpiration declines but tends to be higher than water uptake in the later stage of the vase life and results in negative water balance. A decrease in water potential and stomatal closure subsequently results in loss of turgor pressure. Sucrose with citric acid and BA is the main energy source to maintain pH and osmoticum by synergistic effect which improves water balance and reduces the moisture stress affecting stomatal closure. This is in agreement with the research findings of Larson and Frolich (1969) [17] and Singh *et al*. (2000) [26]. Water deficit in a cut stem standing in vase solution will develop when the rate of water uptake is lower than the rate of transpiration (Van Doorn, 1997) [30].

Bud opening was found to be earlier in treatment H_{10} which might be due to higher level of turgidity and improved metabolic activity which influenced the development of flower buds leading to full opening.

Among the holding solutions, the treatment H_{10} resulted in the longest vase life. This might have been due to cellular disintegration of floret tissues through osmotic injury (Halevy and Mayak, 1974) [20] resulting in early wilting. On the other hand, short vase life of flowers is associated with an increase in respiration and hydrolysis of cell components, a decline in water status (Van Meeteren *et al*., 2001) [31], starch content (Ho and Nichols, 1977), reduction in cell wall polysaccharides, proteins (Halevy and Mayak 1974) [20], nucleic acids (Stead and Moore, 1977) [27] and increase in permeability and ion leakage (Parups and Chan, 1973) [23]. The reduction in vase life has been ascribed to decrease in water content, depletion of carbohydrates, increase of ethylene production and reduction in water uptake of flowers. This is in corroboration with the findings of Goszeynska and Rudnicki (1988) [7].

The results revealed that the freshness and colour fading remained longer upto 12 days of treatment in treatments H_{10} and H_9 and this might be due the better water uptake and water relations in these treatments.

Table 1: Effect of holding solution on Relative Fresh Weight (RFW) of flowering shoots (%)

Treatments	Day 0	Day 1	Day 4	Day 7	Day 10	Day 13
H_1	100	108.20	98.85	76.52	68.97	64.22
H_2	100	108.94	114.10	69.89	76.38	71.42
H_3	100	107.48	106.10	89.00	65.46	61.17
H_4	100	110.04	102.57	82.36	65.05	64.00
H_5	100	113.18	110.49	87.21	71.30	69.32
H_6	100	109.32	122.20	112.97	86.22	72.37
H_7	100	109.34	114.30	96.28	75.98	73.08
H_8	100	109.06	121.32	112.05	83.47	68.87
H_9	100	108.47	124.56	119.60	95.71	85.86
H_{10}	100	116.97	138.87	131.24	98.10	87.08
H_{11}	100	109.86	120.04	108.87	85.30	75.16
H_{12}	100	111.79	117.63	101.95	88.46	77.23
H_{13}	100	108.40	117.81	101.63	71.12	60.62
H_{14} (Control)	100	109.40	108.76	75.82	65.14	60.06
Mean	100	110.03	115.54	97.53	78.33	70.75
S.Ed.	2.88	3.17	3.31	2.77	2.27	2.05
C.D (P=0.05)	5.91	6.50	6.78	5.68	4.66	4.20

Table 2: Effect of holding solution on Leaf water content (g g DW^{-1}) and Dry matter (%) of flowering shoots

Treatments	Leaf Water Content (g g DW^{-1})				Dry matter (%)
	Day 1	Day 4	Day 7	Day 10	
H_1	0.241	0.626	0.245	0.186	41.95
H_2	0.280	0.661	0.272	0.236	44.37
H_3	0.219	0.554	0.209	0.171	40.53
H_4	0.232	0.587	0.239	0.179	41.17
H_5	0.250	0.661	0.263	0.215	43.24
H_6	0.253	0.663	0.303	0.281	44.07
H_7	0.303	0.665	0.321	0.274	47.30
H_8	0.242	0.658	0.247	0.195	42.83
H_9	0.342	0.690	0.417	0.375	49.61
H_{10}	0.395	0.830	0.608	0.405	52.93
H_{11}	0.284	0.668	0.334	0.315	47.37
H_{12}	0.320	0.678	0.359	0.302	47.72
H_{13}	0.147	0.544	0.215	0.208	40.11
H_{14} (Control)	0.138	0.518	0.205	0.105	40.04
Mean	0.260	0.643	0.303	0.246	44.52
S.Ed.	0.008	0.019	0.009	0.008	1.288
C.D (P=0.05)	0.017	0.039	0.019	0.017	2.640

Table 3: Effect of holding solution on vase solution uptake (g $stem^{-1}$ day^{-1})

Treatments	Day 1	Day 4	Day 7	Day 10	Day 13
H_1	8.09	37.73	14.04	12.82	7.03
H_2	8.77	44.49	18.01	16.92	8.31
H_3	7.01	31.79	12.58	10.77	5.78
H_4	7.94	37.36	12.97	11.12	6.21
H_5	8.55	42.42	15.14	14.57	7.55
H_6	9.01	44.63	20.34	21.65	8.37
H_7	9.34	45.43	24.71	21.96	9.03
H_8	8.11	37.85	14.46	13.05	7.37
H_9	9.81	61.49	30.26	30.08	10.29
H_{10}	10.67	61.84	35.10	32.39	11.52
H_{11}	9.46	54.60	25.81	25.40	9.19
H_{12}	9.50	60.54	28.15	26.97	10.04
H_{13}	6.82	29.50	9.70	9.91	5.40
H_{14} (Control)	6.57	24.90	7.36	9.65	4.51
Mean	8.55	43.90	19.19	18.38	7.90
S.Ed.	0.25	1.33	0.60	0.57	0.24
C.D (P=0.05)	0.51	2.73	1.23	1.18	0.48

Table 4: Effect of holding solution on Daily water loss (g $stem^{-1}$ day^{-1})

Treatments	Day 1	Day 4	Day 7	Day 10	Day 13
H_1	4.26	45.01	33.82	32.59	14.48
H_2	4.21	39.40	25.50	24.25	10.15
H_3	4.52	53.34	33.44	37.25	14.91
H_4	4.31	51.85	36.56	33.19	14.55
H_5	4.23	41.20	26.26	24.77	12.54
H_6	3.92	38.98	25.27	23.20	9.63
H_7	3.73	37.14	24.98	20.93	9.15
H_8	4.24	42.48	33.32	30.87	13.43
H_9	3.20	28.22	19.73	16.78	8.10
H_{10}	3.06	26.98	16.34	7.14	5.87
H_{11}	3.34	33.69	23.23	20.44	8.47
H_{12}	3.27	32.40	22.68	18.81	8.20
H_{13}	4.67	54.53	45.26	34.84	15.09
H_{14} (Control)	5.07	55.72	46.91	35.50	16.17
Mean	4.00	40.40	29.52	25.75	11.48
S.Ed.	0.12	1.22	0.88	0.78	0.34
C.D (P=0.05)	0.24	2.49	1.81	1.60	0.70

Table 5: Effect of holding solution on Water balance (g $stem^{-1}$ day^{-1})

Treatments	Day 1	Day 4	Day 7	Day 10	Day 13	Cumulative Water balance (g/spike)
H_1	3.83	-7.28	-19.78	-19.77	-7.45	-50.45
H_2	4.56	5.09	-7.49	-7.33	-1.84	-7.01
H_3	2.49	-21.55	-20.86	-26.48	-9.13	-75.53
H_4	3.63	-14.49	-23.59	-22.07	-8.34	-64.86
H_5	4.32	1.22	-11.12	-10.20	-4.99	-20.77
H_6	5.09	5.65	-4.93	-1.55	-1.26	3.00
H_7	5.61	8.29	-0.27	1.03	-0.12	14.54
H_8	3.87	-4.63	-18.86	-17.82	-6.06	-43.50
H_9	6.61	33.27	10.53	13.30	2.19	65.90
H_{10}	7.61	34.86	18.76	25.25	5.65	92.13
H_{11}	6.12	20.91	2.58	4.96	0.72	35.29
H_{12}	6.23	28.14	5.47	8.16	1.84	49.84
H_{13}	2.15	-25.03	-35.56	-24.93	-9.69	-93.06
H_{14} (Control)	1.50	-30.82	-39.55	-25.85	-11.66	-106.38
Mean	4.54	2.40	-10.33	-7.38	-3.58	-14.35
S.Ed.	0.14	0.59	0.54	0.48	0.18	1.70
C.D (P=0.05)	0.29	1.22	1.11	0.99	0.36	3.47

Table 6: Effect of holding solution on vase life, Freshness and colour retention index

Treatments	Days taken for flower bud opening (Days)	Vase life (Days)	Freshness (%)	Colour retention (%)
H_1	5.00	11.38	88.40	85.13
H_2	4.75	13.51	89.24	88.89
H_3	5.83	10.23	87.51	77.78
H_4	5.20	10.86	88.39	80.32
H_5	4.83	12.66	89.09	87.22
H_6	4.75	14.32	89.24	90.32
H_7	4.50	14.70	89.71	94.81
H_8	5.00	11.81	88.40	86.11
H_9	4.20	16.21	92.64	98.06
H_{10}	3.40	17.84	92.64	98.32
H_{11}	4.25	14.70	91.20	95.36
H_{12}	4.20	15.08	91.20	96.72
H_{13}	5.94	9.16	87.04	72.22
H_{14} (Control)	6.14	8.33	84.68	70.39
Mean	4.86	12.91	89.24	87.26
S.Ed.	0.14	0.38	2.58	2.54
C.D (P=0.05)	0.29	0.78	5.28	5.21

Conclusion

With regard to the post harvest holding treatments, it is recommended to treat the flower shoots in a holding solution containing NSP 75 ppm + 8 – HQ 150 ppm + sucrose 2 per cent to extend the post harvest vase life of lilium flowers substantially.

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