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Effect of Post-harvest Treatments on Vase Life quality of *Dendrobium* orchid *cv.* Sonia-17

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ABSTRACT: Dendrobium, one of the largest genera of the family Orchidaceae, is a popular tropical orchid, grown commercially as a cut flower. The experiment was carried out in the laboratory of Howrah Krishi Vigyan Kendra, Jagatballavpur, Howrah, West Bengal. The main objective was to improve the vase life and quality of the cut flowers of dendrobium. The cut spikes were pulsed with solutions containing different concentrations and combinations of 8-HQS (Hydroxyquinoline Sulfate), silver nitrate, sodium hypochlorite, sucrose, and nano silver (NS). Pulsing time was for 24 hours. The treated flowers were then submerged in distilled water that was replaced every 2 days until the experiment was over. Results demonstrated that maximum water uptake (15.78 g spike^{-1}), water balance (4.63 g spike^{-1}), fresh weight (28.38 g spike^{-1}) and vase life (21.31 days) with minimum un-opened and abscised buds per spike (8.12%) were found when the spikes were pulsed with 8-HQS (200ppm) and nano silver @ 5 g lt^{-1} along with 4% sucrose. Maximum bud opening (89.94%) and delayed floret senescence were recorded when flower spikes were pulsed with nano silver @ 5 g lt^{-1} in combination with sodium hypochlorite @ 7 ml.lt^{-1} and 4% sucrose. A minimum vase life of 13.05 days as well as the lowest bud opening percentage (65.99%) were recorded when the spikes were pulsed with distilled water only. According to the results of the experiment, cut dendrobium flowers of the variety Sonia-17 should be pulsed with 8-HQS (200 ppm) along with nano silver @ 5 g lt.$^{-1}$ and 4% sucrose in order to reduce microbial growth in the vase solution and extend the vase life of the flowers. Additional research is required to improve the post-harvest attributes of dendrobium cut flowers using varying pulsing durations.

Keywords: Dendrobium orchid, vase life, pulsing, 8-HQS, Nano Silver, sucrose.

INTRODUCTION

Orchids are widely grown for commercial purposes as cut flowers because of their high demand in both domestic and foreign markets. One of the biggest genera in the orchidaceae family, dendrobium is a popular tropical orchid that is cultivated for the production of cut flowers commercially. Post-harvest rejection of cut flowers occurs most often. It's crucial to develop post-harvest remedies to prevent problems of vase life. The post-harvest life of cut flowers refers to how long a cut flower keeps looking fresh while being presented in a vase or how long it lasts in a vase solution. The physiological processes that take place in the leaves, stem, flower buds, leafless peduncles, or scapes linking the bud to the stem result in the post-harvest behaviours of flowers. Excessive water loss, a decline in respirable substrates, and sensitivity to exogenous or endogenous ethylene, which hastens flower ageing and wilting, are problems with cut flowers' vase life (Hew, 1994).

One of the primary causes of the short vase life of many cut flowers is the presence of microorganisms like bacteria, fungi, or yeast in the holding solutions. During the cut flower's vase life, all microorganisms block water absorption by disrupting xylem tissue. These obstructions could result from microbial growth, tylose production, material sedimentation in xylem channel lumens, or the growth of air emboli in the vascular system (Twumasi *et al*., 2005). In order to extend the vase life, preserve bloom size, and improve colour, chemical formulations known as floral preservatives are applied. Pulsing is the process by which chemical solutions containing sugars and germicides are absorbed through the lower cut bases of flower stems. The growers short-term pre-shipment procedure known as "pulsing" should have an impact on the bloom for the duration of its shelf life. The opening of buds after storage is improved by pulsing flowers before storage (Somani**,** 2009). The vase life of cut flowers is increased by pulsing with 4 mM STS for 10 minutes in the case of *Aranda* orchids (Hew *et al.*, 1987), and in

Dendrobium hybrid 'Pompadour' by pulsing with 25 ppm $AgNO_3$ + 135 $Na_2S_2O_3$, $5H_2O$ for 30 minutes (Hew and Yong 2004).

The highest vase life of 21.33 days was recorded after pulsing was conducted with 4% sucrose + 400 ppm HQS for six hours in dendrobium cv. Sonia-17 (Jomy, 1998). When inflorescences were pulsed with 6% sucrose and 400 ppm HQS, the highest recorded sugar content (27.64%) in the flowers was found (Jomy and Sabina 2002). Bhatia *et al*. (2002) studied the effects of pulsing, dry storage (2°C) and holding solution on the vase life of carnation cut flowers cv. Impala (standard) and purple chopin (spray). The cut flowers were pulsed by distinct holding solutions like STS (25, 50, 75, 100 ppm) and HQC (25, 50, 75, 100 ppm) along with 2% sucrose for different durations (4, 6 and 8 hrs) and it was observed that 100 ppm HQC + 2% sucrose resulted in increased flower diameter, water uptake and reduced fresh weight losses. The suppression of microbial growth in vase solution was found to delay wilting in many cut flowers. Nano silver is a novel antibacterial compound that can kill 650 species of bacteria in water (Furno *et al*., 2004).

Liu *et al*. (2009) conformed that pulsing of 15 mg lt^{-1} nano silver along with 2% sucrose improved the vase life three cut flowers like carnation (19.9 ± 2.6 days), rose (9.6 ±1.3 days) and gerbera (8.9 ± 0.3 days) over control. The pulse treatment of cut flowers with nano silver, 8-HQS, sodium hypochlorite, and sucrose in various combinations increases mineral salt intake, reduces transpiration rate by influencing stomatal closure, and results in optimal supply of carbohydrates and improved vase life. The goal of the current study was to use various pulse treatments to prolong the vase life of cut spikes of the orchid dendrobium var. Sonia-17.

MATERIAL AND METHODS

The present investigation on Effect of post-harvest treatments on vase life quality of *Dendrobium* orchid cultivar Sonia-17 was carried out in the laboratory of Howrah Krishi Vigyan Kendra, Jagatballavpur, Howrah, West Bengal.

Treatment details

T_1	➢	Control (Distilled water)
T_2	➢	8-HQS (200 ppm) + 4% sucrose
T_3	➢	$AgNO_3$ (30ppm) + 4% sucrose
T_4	➢	Nano silver @ 5 g lt^{-1}+ 4% sucrose
T_5	➢	Sodium hypochlorite @ 7 ml lt^{-1}+ 4% sucrose
T_6	➢	8-HQS(200ppm) + $AgNO_3$ (30ppm) + 4% sucrose
T_7	➢	8-HQS(200ppm) + Nano silver @ 5 g lt^{-1}+ 4% sucrose
T_8	➢	8-HQS(200ppm) + Sodium hypochlorite @7 ml lt^{-1}+ 4% sucrose
T_9	➢	$AgNO_3$ (30ppm) + Sodium hypochlorite @7 ml lt^{-1} + 4% sucrose
T_{10}	➢	Nano silver @ 5 g lt^{-1}+ Sodium hypochlorite @7 ml lt^{-1} + 4% sucrose

The required number of conical flasks were washed, weighed, and labelled as per the schedule of treatments. Similarly, a calculated quantity of each chemical, viz., 8-HQS, $AgNO_3$, Sodium hypochlorite, Nano-silver, and Sucrose, were weighed and then dissolved in the required quantity of distilled water to make the required concentration as per the technical programme.

Dendrobium flower spikes were collected from the plants grown under the shade house of Howrah KVK. Harvesting was done in the morning. The flowers were harvested at 3–4 lower buds' opening stage. Harvesting was carried out manually with care to minimise damage and mechanical injuries. Pre-cooling was accomplished by immediately immersing in cold water. Post-harvest precautions include keeping the basal of the spike in water till it reaches the laboratory and a slant cut to a uniform length of 5 cm under distilled water to remove any surface embolism. The flower spikes were immediately transferred to a vase containing a different pulsing solution. The experiment was conducted in a well-ventilated, well-illuminated laboratory.

Cut spikes were pulsed with solutions containing different concentrations and combinations of HQS, silver nitrate, sodium hypochlorite, sucrose, nano silver, etc., and control stems were treated with distilled water. Pulsing time was for 24 hours. The treated flowers were then submerged in distilled water that was to be replaced every 2 days until the experiment was over.

The observations on various quality parameters and vase life on alternate days till the termination of experiment were recorded. When the petals showed 60% wilting, the vase life was considered to be over.

The dataset was subjected to statistical analysis as per the procedure outlined by Panse and Sukhatme (1985). Results from vase life experiments were analyzed using analysis of variance (ANOVA) and F-test analysis. The least significant difference (LSD or CD) was used for the comparison between treatments during vase life.

RESULT AND DISCUSSION

Water uptake. Water uptake was recorded at maximum (15.78 g $spike^{-1}$) with 8-HQS(200ppm) + nano silver @ 5 g lt^{-1} + 4% sucrose (T_7) which is statistically at par with nano silver @ 5 g lt^{-1} + sodium hypochlorite @7 ml lt^{-1} + 4% sucrose (T_{10}) solution in comparison to minimum absorption (8.65 g) for control (T_1). Water uptake trends revealed significant differences among treatments as the days progressed (Table 1). Chemical preservatives like nano silver and 8-HQS prevent microbial growth, avoiding vascular obstruction and thus making it easier for spikes to absorb water. This suggests that the synergistic effect of those chemicals on increasing vase life was the result of a suppression of microbial growth (Ketsa *et al.*, 1995), resulting in increased water uptake. 8-HQS (8-hydroxyquinoline sulphate) is a major anti-microbial agent which prevents the buildup of microorganisms in the xylem vessels and hence maintains the water uptake rate at an adequate concentration of 200-600 mg lt^{-1} (Fonseca *et al*., 2017). Meman and Dabhi (2007) also observed that applying chemical preservatives and sucrose in pulsing to cut gerbera improved solution uptake and vase life.

Table 1: Effect of post-harvest treatments on water uptake (g $spike^{-1}$).

Treatment	2nd day	5th day	10th day	15th day	20th day	25th day	Total (g $spike^{-1}$)
T_1	2.62	4.03	1.69	0.31	-	-	8.65
T_2	3.21	3.70	3.84	1.33	0.41	-	12.49
T_3	3.44	4.32	2.86	0.68	0.22	-	11.52
T_4	3.27	3.95	3.38	1.96	1.16	-	13.71
T_5	3.55	4.39	2.69	0.53	0.10	-	11.26
T_6	3.84	3.92	4.02	1.57	0.57	0.01	13.92
T_7	3.95	5.08	3.16	1.68	1.32	0.59	15.78
T_8	3.86	3.94	3.07	1.96	0.58	-	13.40
T_9	3.54	3.78	2.68	2.13	0.67	-	12.79
T_{10}	4.17	4.88	2.79	2.03	1.47	0.27	15.62
$CD_{0.05}$	0.32	0.49	0.24	0.18	0.33	0.06	0.68
SEm(±)	0.11	0.17	0.08	0.06	0.11	0.02	0.23

Water loss. Different pulsing treatments significantly influenced the water loss and transpiration loss of individual flowers (Table 2). An increasing trend in water loss was observed up to the 10th day after pulsing, after which it started decreasing in the case of most of the treatments and reached a minimum value at the end of their respective vase lives. Water loss was recorded highest (2.93 g $spike^{-1}$) on the 10th day when the flowers were pulsed with 8-HQS (200 ppm) + 4% sucrose (T_2). A minimum water loss (2.42 g $spike^{-1}$) was recorded with T_{10}. The total water loss was ranged from 7.22 g $spike^{-1}$ to 11.24 g $spike^{-1}$ with different treatments. This may be attributed to the partial closure of the stomata. Pulsing with 8-HQS, nano-silver, and sodium hypochlorite reduced stomatal aperture and inhibited floret transpiration. Sooch *et al.* (2002) studied the effect of pulsing with chemicals on the vase life of cut gerbera and observed that all the pulsing solutions having silver, sodium hypochlorite, sucrose etc. help in maintaining water relations through their influence on stomata closure and biocidal properties.

The presence of silver and 8-HQC in the treatments for pulsing enhanced water uptake in the early stages due to the physical and biological alterations of the cut stems. This provides insight on stem cell conductivity reduction and water transportation, which lead to stem occlusions rather than occlusions caused by microbes. It works by lowering the pH of the vase solution and thus deactivates the enzymes responsible for vascular occlusion (Adam and Eldeeb 2021). However, 8-HQS works more effectively when combined with sugar (Asrar, 2012). Liu *et al.* (2009) also reported that pulsing with nano-siver inhibits bacterial growth in the vase solution and at the cut stem ends of cut gerbera flowers.

Table 2: Effect of post-harvest treatments on water loss/transpiration loss (g $spike^{-1}$).

Treatment	2nd day	5th day	10th day	15th day	20th day	25th day	Total (g $spike^{-1}$)
T_1	1.8	2.36	2.5	0.56	0	0	7.22
T_2	2.02	2.12	2.93	1.54	0.46	0	9.08
T_3	1.65	2.74	2.81	0.99	0.27	0	8.46
T_4	1.74	2.16	2.47	2.02	1.93	0	10.33
T_5	1.41	1.79	2.59	2.36	0.16	0	8.31
T_6	1.73	2.11	2.48	2.29	1.27	0.08	9.96
T_7	2.25	1.95	2.44	1.63	1.78	1.1	11.15
T_8	2.1	2.44	2.77	2.07	0.32	0	9.70
T_9	1.9	2.14	2.68	2.07	0.72	0	9.51
T_{10}	1.66	1.78	2.42	2.31	2.02	1.05	11.24
$CD_{0.05}$	0.19	0.19	0.32	0.21	0.17	0.13	0.54
SEm(±)	0.06	0.07	0.11	0.07	0.06	0.04	0.18

Water uptake ratio. Cut flower water uptake ratio is an important parameter for the vase life of cut flowers. The water loss and water uptake ratio were recorded more during the end of the vase life of the respective flower spike. On the 25th day after pulsing, a maximum water loss and water uptake ratio (3.88) was found when pulsing was done with nano silver @ 5 g lt^{-1} + sodium hypochlorite @7 ml lt^{-1} + 4% sucrose (T_{10}). Thus, flowers of dendrobium showed variable water loss and water uptake ratios under the influence of various treatments. Pulsing solution having silver played a vital role. Silver ions (Ag+) kill microbes because they loosen the cell well, reduce the cytoplasmic membrane's thickness, and condense DNA molecules (Carrillo-opez *et al*., 2016).

Table 3: Effect of post-harvest treatments on water uptake ratio.

Treatment	2nd day	5th day	10th day	15th day	20th day	25th day
T_1	0.69	0.59	1.49	1.83	-	-
T_2	0.63	0.58	0.77	1.16	1.14	-
T_3	0.48	0.63	0.98	1.46	1.24	-
T_4	0.54	0.55	0.73	1.03	1.69	-
T_5	0.40	0.41	0.96	1.47	1.71	-
T_6	0.45	0.54	0.62	1.46	2.24	0.22
T_7	0.57	0.38	0.77	0.97	1.36	1.90
T_8	0.55	0.62	0.91	1.05	0.87	-
T_9	0.54	0.57	1.00	0.98	1.24	-
T_{10}	0.40	0.37	0.87	1.14	1.39	3.88
$CD_{0.05}$	0.07	0.07	0.19	0.60	0.55	0.75
SEm(±)	0.02	0.02	0.06	0.20	0.18	0.25

Water balance: The data pertaining to the water balance of dendrobium flowers as influenced by different treatments is presented in Table 4. In the present experiment, treatments with 8-HQS, nano silver, as well as sodium hypochlorite in different combinations along with sucrose decreased water loss and maintained optimal water balance. Water balance followed an increasing trend up to the 5th day and a decreasing trend onwards after pulsing for most of the treatments. The maximum water balance (4.63 g spike[1]) was recorded when the spikes were treated with 8-HQS (200ppm) + Nano silver @ 5 g lt^{-1} + 4% sucrose (T_7), followed by the treatment combination of nano silver @ 5 g lt^{-1} + Sodium hypochlorite @7 ml lt^{-1} + 4% sucrose (T_{10}) as 4.37 g spike[1]. Most of the variations among the treatments were significant. In this experiment, sucrose was a common factor in all the cases. The moment the flower stem is submerged in a sugar solution, bacteria begin to grow at the cut end, preventing the stem from absorbing water from the solution (Muriithi and Ouma 2011). Cut stems were therefore soaked in a preservation solution combining sugar and biocide, which inhibits microbial development and improves water absorption to retain floral turgidity in order to prolong the vase life. Chemical preservatives employed in the present study also had a significant impact on water balance. Sooch *et al*. (2002) studied the effect of pulsing on the vase life of cut gerbera and observed that the pulsing solutions having silver, sodium hypochlorite, sucrose etc. help in maintaining water relations through their influence on stomata closure and biocidal properties.

Table 4: Effect of post-harvest treatments on water balance (g $spike^{-1}$).

Treatment	2nd day	5th day	10th day	15th day	20th day	25th day	Total (g $spike^{-1}$)
T_1	0.82	1.67	-0.81	-0.25	-	-	1.44
T_2	1.19	1.58	0.90	-0.21	-0.05	-	3.41
T_3	1.79	1.58	0.06	-0.31	-0.05	-	3.07
T_4	1.52	1.78	0.91	-0.06	-0.78	-	3.38
T_5	2.14	2.60	0.10	-1.83	-0.06	-	2.95
T_6	2.11	1.81	1.54	-0.72	-0.70	-0.07	3.96
T_7	1.69	3.13	0.73	0.05	-0.47	-0.51	4.63
T_8	1.76	1.49	0.29	-0.10	0.26	-	3.70
T_9	1.64	1.65	0.00	0.06	-0.05	-	3.29
T_{10}	2.51	3.10	0.38	-0.28	-0.55	-0.79	4.37
$CD_{0.05}$	0.32	0.48	0.48	0.29	0.37	0.17	0.84
SEm(±)	0.11	0.16	0.16	0.10	0.12	0.06	0.28

Fresh weight and fresh weight changes. The data on fresh weight showed significant variations among different pulsing treatments (Tables 5). An increase in fresh weight up to the 10th day after pulsing was found and a decreasing trend was recorded onwards for most of the treatments except T_1 and T_8. Maximum fresh weight (28.38 g $spike^{-1}$) was recorded on the 10th day after pulsing with 8-HQS(200ppm) + nano silver @ 5 g lt^{-1} + 4% sucrose (T_7). An increase in fresh weight and water uptake ultimately increased the vase life of the spike after pulsing. This might be due to a reduced rate of senescence, which improved vase life by maintaining respiration rate and cell membrane integrity. Jomy (1998) reported that the use of a combination of 4% sucrose and 400 ppm 8-HQS enhanced the fresh weight and vase life of dendrobium flowers. Similar findings were also reported by Yoo and Kim (2003).

As evident from the data (Table 5), it was observed that maximum fresh weight changes (34.34%) was recorded on the 10^{th} day after pulsing with nano silver @ 5 g lt^{-1} in combination with sodium hypochlorite @7 ml lt^{-1} and 4% sucrose (T_{10}). A similar observation was also reported by Mirjalili (2015) that silver used as a post-harvest chemical showed anti-microbial and ethylene binding inhibitor properties. Silver used in combination with sucrose 5%, improves the fresh weight, flower opening percentage and enhances vase life up to 18 days of tuberose spikes (Selvaraj *et al.*, 2014).

Days to initiation of floret senescence. Data in Table 7 revealed that flower spikes pulsed with nano silver @ 5 g lt^{-1} in combination with sodium hypochlorite @7 ml lt^{-1} and 4% sucrose (T_{10}) remained fresh for the longest time. Floret senescence was started at 17.02 days after harvesting. The earliest floret senescence was found with control (T_1). This may be because of that nano silver releases Ag+, which has been reported to interact with cytoplasmic components and nucleic acids, to inhibit respiratory chain enzymes and to interfere with membrane permeability (Park *et al*., 2005). Nanometer sized silver (Ag+) particles are recognized as having a stronger effect of inhibiting many bacterial strains and other micro-organisms than silver in various oxidation states. Due to high surface area to volume ratio of silver nano-particles and strong antibacterial activity, it could suppress the growth of bacterial population in vase solution and in the xylem vessels as well (Basiri *et al.*, 2011).

Table 5: Effect of post-harvest treatments on fresh weight (g spike^{-1}).

Treatment	2^{nd} day	5^{th} day	10^{th} day	15^{th} day	20^{th} day	25^{th} day
T_1	20.74	21.88	20.43	18.37	0.00	0.00
T_2	23.13	24.43	24.92	21.15	20.52	0.00
T_3	22.45	23.90	24.16	20.84	18.85	0.00
T_4	22.75	25.25	27.51	24.28	19.33	0.00
T_5	22.58	23.24	24.34	20.50	19.21	0.00
T_6	24.91	27.61	28.63	24.14	20.81	19.61
T_7	24.16	27.10	28.38	24.54	23.43	20.36
T_8	25.17	26.02	25.62	22.81	20.36	0.00
T_9	24.59	25.38	25.77	22.87	20.24	0.00
T_{10}	23.42	26.22	28.14	23.11	22.86	19.84
$CD_{0.05}$	2.52	3.09	2.27	1.94	2.93	0.91
SEm(±)	0.85	1.04	0.77	0.65	0.99	0.31

Table 6: Effect of post-harvest treatments on fresh weight changes (%).

Treatment	2^{nd} day	5^{th} day	10^{th} day	15^{th} day	20^{th} day	25^{th} day
T_1	-1.38	4.06	-2.84	-12.66	0.00	0.00
T_2	6.92	12.96	15.20	-2.20	-5.15	0.00
T_3	2.86	9.50	10.66	-4.54	-13.64	0.00
T_4	8.90	20.89	31.71	16.21	-7.45	0.00
T_5	4.76	7.84	12.96	-4.89	-10.87	0.00
T_6	10.97	23.00	27.51	7.53	-7.31	-12.65
T_7	13.00	26.75	32.76	14.77	9.45	-4.76
T_8	13.53	17.35	15.56	2.89	-8.18	0.00
T_9	13.44	17.08	18.87	5.49	-6.64	0.00
T_{10}	12.22	25.64	34.84	10.75	9.55	-4.92
$CD_{0.05}$	N/A	14.16	10.54	8.97	13.72	4.21
SEm(±)	3.92	4.77	3.55	3.02	4.62	1.42

Table 7: Effect of post-harvest treatments on days to initiation of floret senescence, un-opened and abscised buds, bud opening and total vase life.

Treatment	Floret senescence (Days)	Un-opened and abscised buds per spike (%)	Bud opening per spike (%)	Total vase life (Days)
T_1	6.80	19.43	65.99	13.05
T_2	10.50	18.51	68.98	16.31
T_3	8.80	16.78	70.80	15.85
T_4	13.20	11.26	84.95	19.59
T_5	12.80	14.60	71.77	15.03
T_6	14.00	9.19	89.52	20.02
T_7	16.70	8.12	89.65	23.53
T_8	13.90	13.38	81.09	17.84
T_9	14.00	12.45	80.08	17.79
T_{10}	17.02	9.19	89.94	21.31
$CD_{0.05}$	2.79	2.23	4.03	2.57
SEm(±)	0.94	0.75	1.36	0.87

Un-opened, abscised buds and bud opening. As evident from recorded data on Table 7, different pulsing treatments significantly influenced the un-opened and abscised buds per spike**.** Minimum un-opened and abscised buds per spike (8.12%) were found with 8-HQS (200ppm) + Nano silver @ 5 g lt^{-1} + 4% sucrose (T_7). Control had the most un-opened and abscised buds (19.43%). Highest bud opening (89.94%) was reported when the flower spikes were pulsed with nano silver @ 5 g lt^{-1} + sodium hypochlorite @7 ml lt^{-1} + 4% sucrose (T_{10}). Relevant results were also reported by different researchers. Ketsa *et al.* (2001) reported that a preservative solution containing 225 ppm HQS, 30 ppm $AgNO_3$, and 4% glucose increased bud opening and the time to wilting of the open florets of dendrobium cv. 'Ceasar'. The combined effect of 8-HQS as a biocide and Ca (calcium) as a flow resistance reducer maintains turgidity in rose petals and leaves. Also, reduce losses in fresh weight with an increased percentage of opened flowers (Cortes *et al*., 2011). Silver nitrate increases flower opening percentage, and enhances vase life up to 18 days when used in combination with 5% sucrose solution (Selvaraj *et al*., 2014). This combination improves water uptake rate and delays the wilting flower rate in dendrobium (Ajith Kumar *et al*., 2013).

Total vase life. The vase life of dendrobium cut flowers was significantly extended after using different post-harvest chemicals as pulsing as compared to the control (Table 7). Among the different pulsing treatments of the flower spike, maximum vase life of 23.53 days was recorded with 8-HQS(200ppm) + nano silver @ 5 g lt^{-1} + 4% sucrose (T_7) followed by nano silver @ 5 g lt^{-1} + Sodium hypochlorite @7 ml lt^{-1} + 4% sucrose (T_{10}). The presence of HQS in the treatments increased water uptake, which might be due to the physical and biological changes of the stem (Marousky, 1972).

These results may be due to the role of biocides as anti-microbial agents, and hence, they might reduce stem plugging. Sugars alone, however, tend to promote microbial growth. However, the combination of sugars and biocides might have extended the vase life of cut flowers (Halevy and Mayak 1981). The pulsing treatment of cut flowers with nano silver, 8-HQS, sodium hypochlorite, and sucrose at different combinations might have increased mineral salt uptake, reduced rate of transpiration through its influence on stomatal closure, and optimum supply of carbohydrates and ultimately resulted in enhanced vase life. Sucrose is known to decrease the water potential of the petals and enhance their ability to absorb water. By pulsing with sucrose and mineral salts, cut dendrobium may have a prolonged vase life due to decreased enzymatic activity. Utilizing chemical preservatives helps cut flowers retain their freshness longer by promoting water absorption, increasing fresh weight, reducing solute exosmosis, and preserving water balance. Chen *et al*. (2004); Banaee *et al.* (2013) reported that pulsing with sucrose and chemical preservatives at an optimum level for a specific period helps in maintaining water relations and enhances the vase life of cut gerbera. Liu *et al*. (2009) conformed that pulsing of 15 mg lt^{-1} nano silver along with 2% sucrose improved the vase life of three cut flowers like rose (9.6 ±1.3 days), carnation (19.9 ± 2.6 days) and gerbera (8.9 ± 0.3 days) over control.

CONCLUSION

Based on the outcome obtained from the experiment by using different biocides as pulsing chemicals along with sugar, the biocides containing 8-HQS and nano-silver with other combinations showed improved post-harvest life and quality of dendrobium cut flowers. In this study, it was revealed that 8-HQS (200 ppm) in combination with nano silver @ 5 g lt^{-1} and 4% sucrose was the most effective treatment for reducing microbial growth in the floral tissue, which had increased vase life, bud opening percentages, and fresh weight in cut dendrobium flowers.

FUTURE SCOPE

Pulsing treatment was beneficial for the improvement of the post-harvest attributes of cut flowers of dendrobiun orchids towards better marketing. More research is needed to enhance the post-harvest qualities of cut dendrobium blooms by utilizing different pulsing durations.

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