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EFFECT OF HOLDING SOLUTIONS AND OPTIMIZATION OF HARVEST STAGE ON DENDROBIUM ORCHIDS CV. SONIA 17 FOR IMPROVING THE VASE LIFE OF CUT SPIKES

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ABSTRACT

The present investigation entitled "Effect of holding solutions and optimization of harvest stage on Dendrobium Orchids cv. Sonia 17 for improving the vase life of cut spikes" was carried out at Horticulture Research station, Chintapalli, Visakhapatnam district of Andhra Pradesh during two consecutive years of 2016-17 and 2017-18. The experiment was laid out in a completely randomized design with 9 treatments and each treatment replicated thrice. The data recorded on various parameters *viz.,* Physiological loss of weight, Water uptake, Days to fading of first flower, Days to fading of last flower, Percent bud opening per spike, Number of unopened abscised buds per spike, Vase life and Total microbial count and were statistically analyzed. Among all the treatments, holding solution containing 75 % flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose GA_3 @ 50 ppm showed significantly best results when compared to other treatments.
Keywords: Dendrobium, Sonia 17, Cut flower, Holding solutions, Stage of harvest.

Introduction

Orchids are the most beautiful flowers in God's creation and have conquered the cut flower industry all over the world during the last few decades. Orchid cut flowers have emerged as leader in the International market and have immensely contributed to the economy of several developed and developing countries. They are valued for cut flower production and as potted plant in commercial floriculture owing to the wide range of colours, shapes, sizes and fragrance they display. Orchids are excellent for garden and can be grown in beds, pots, baskets, split hollows of bamboo pieces etc. They are marketed globally as cut flowers for making corsages, floral arrangements and boquets. They are also suitable for interior decoration and remain fresh for many days. They comprise the largest family (Orchidaceae) of flowering plants with 25,000 to 35,000 species belonging to 600-800 genera (Chowdhery, 2001).

Dendrobium is the second largest orchid genera consisting of more than 16,000 species (Puchooa, 2004). Countries including Thailand, Taiwan, China, Phillipines, Germany, United States, Japan and India are major producers of *Dendrobium* orchids. Most *Dendrobium* species are epiphytic, sympodial orchids and are from subtropical and tropical regions and is a popular genus for cut flower production. Many growers in the states of Karnataka, Kerela, Tamilnadu and Andhra Pradesh are cultivating *Dendrobium* on a commercial scale. The flower spikes of *Dendrobium* are extremely beautiful, medium sized with flowers numbering between 5-20, in colours such as white, mauve, pink, red, blue, purple, yellow and are highly popular in the National and International market.

Orchids are used in Indigenous system of medicine, particularly in Ayurveda.

In the present cut flower industry, *Dendrobium* cv. Sonia 17 has taken a prominent place due to colour, attractiveness and long season of bloom. The most important barriers in the marketing and commercialization of many cut flowers are their short vase life and their inability to withstand stresses during storage or transit (Zamani *et al.,* 2011). Correct stage of harvesting is essential as it not only influence keeping quality, but also adds to the beauty of the spike. Vase life of *Dendrobium*s has been much influenced by ethylene production and respiration which are the major physiological processes that are responsible for deterioration and short life. In cut flower industry about 10-30 % losses occur due to postharvest damage and mishandling practices. Further, it could be possible to extend the postharvest life of flowers by using different preservative solutions. Appropriate postharvest management of any cut flower is of utmost important to ensure the long lasting quality. Keeping all these considerations in view an experiment was taken up to in order to improve the vase life of cut spikes and also to standardize the stage of harvest.

Materials and Methods

The cut flowers of *Dendrobium* Orchids cv. Sonia 17, employed for the studies were procured from the centre of excellence, Chintapalli (Visakhapatnam district). The flowers are harvested at 50% flower opening stage and 75% flower opening stage commercial for the experiment. Immediately after harvesting, the flowers were pre-cooled by dipping the basal portions of the cut flowers in a bucket containing water, then the stem is plugged with cotton containing water and brought immediately to the laboratory for imposing the treatments. Completely randomized design was set with three replications having five spikes in each replication. Postharvest observations including Physiological loss of weight (%), Water uptake (ml), Days to fading of first flower (Days), Days to fading of last flower (Days), Percent bud opening per spike (%), Number of unopened abscised buds per spike, Vase life (Days) and Total microbial count (CFU/ml) were recorded.

Results and Discussion

Physiological loss of weight (%)

The data pertaining to the effect of holding solutions and harvest stage on physiological loss of weight (%) of *Dendrobium* orchids cv. Sonia 17 is presented in Table 1. The data was recorded on initial day and at final day. Significant differences were observed in physiological loss of weight among different treatments in *Dendrobium* orchids cv. Sonia 17.

Data revealed that among all the treatments, significantly minimum physiological loss of weight was observed in cut spikes held in holding solution containing 75 % flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose (49.23%) while, maximum physiological loss of weight was observed in control (fully opened flowers kept in water) (75.03%).

The 75% flowers open spike harvest stage was recorded minimum physiological loss of weight when compared to 50% flowers open spike harvest stage.

The *Dendrobium* spikes held in holding solution of 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose recorded less physiological loss of weight might be due to the maintenance of water relations, mainly by plugging the vascular vessels. Sucrose plays an important role in improving the water balance of cut flowers by affecting the osmotic potential of the cut flowers and the water holding capacity of the tissues allowing less water to be transpired (Saravanan, 2001 in *Dendrobium*).

Water uptake (ml)

The data pertaining to the effect of holding solutions and harvest stage on water uptake of *Dendrobium* orchids cv. Sonia 17 is presented in Table 1. It was measured after removing cut flowers from the water at initial day and at final day. Significant differences were observed in water uptake among different treatments in *Dendrobium* orchids cv. Sonia 17.

The treatments had significant influence on water uptake and maximum water uptake was observed in cut spikes held in holding solution containing 75% flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4 % sucrose (9.48 ml) while minimum water uptake was observed in control (fully opened flowers kept in water) (4.25 ml).

Based on results obtained, it may be concluded that maximum water uptake was recorded when 75% flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose.

Lower water uptake by cut flowers is often due to occlusions located mainly in the basal stem end (Hee *et al.* 2006) and microorganisms and their decay products are a common cause of stem end blockage (Van Doorn, 1997 and Williamson *et al.,* 2002).

Sucrose being anti-desiccant is known to increase moisture retention serves as substitute for respirable substrate *i.e.* naturally depleting carbohydrate in flowers and maintains osmotic balance in petals that contributes to water uptake and fresh weight retention in cut flower. Further, anti-ethylene properties of sucrose on the ethylene biosynthesis and ethylene sensitivity in cut flowers are well known (Van Doorn and Woltering 2004). The anti-microbial activities of 8-HQC inhibited vascular blockage of microbial origin and its quinoline esters chelated metal ions of enzymes inhibited physiological blockage which also improved water uptake. Silver nitrate and citric acid were seemed to act as germicide, decreased the microbial population and increased the solution uptake. Citric acid can alleviate water uptake and extended vase life due to its antiembolism trait (Bhattacharjee *et al.* 1993).

Days to fading of first flower

The data pertaining to the effect of holding solutions and harvest stage on days for fading of first flower of *Dendrobium* orchids cv. Sonia 17 is presented in Table 1. The number of days taken to fading of first flower was counted and recorded. Significant differences were observed in days to fading of first flower among different treatments in *Dendrobium* orchids cv. Sonia 17.

Among all the treatments, maximum days for fading of first flower was recorded in cut spikes held in holding solution containing 75% flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose (18.90 days) while, minimum days to fading of first flower was observed in control (fully opened flowers kept in water) (9.66 days).

Based on results obtained, it may be concluded that days taken to fading of first flower was recorded maximum when 75% flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose.

Days to fading of last flower

The data pertaining to the effect of holding solutions and harvest stage on days to fading of last flower on *Dendrobium* orchids cv. Sonia 17 is presented in Table 1. The number of days taken to fading of last flower was counted and recorded. Significant differences were observed in days to fading of last flower among different treatments in *Dendrobium* orchids cv. Sonia 17.

Among all the treatments, significantly maximum days to fading of last flower was observed in cut spikes held in holding solution containing 75% flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4 % sucrose (52.32 days) while, minimum days to fading of last flower was observed in control (fully opened flowers kept in water) (32.62 days).

Based on results obtained, it may be concluded that days taken to fading of last flower was recorded maximum when 75% flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose.

The *Dendrobium* spikes kept in holding solution of 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose improved the water uptake via the cut flowers resulted in better water balance and flower freshness and reduced early wilting of first and last flowers.

Per cent bud opening per spike (%)

The data pertaining to the effect of holding solutions and harvest stage on percent bud opening per spike of *Dendrobium* orchids cv. Sonia 17 is presented in Table 1. The per cent number of opened buds per spike was calculated and recorded. Significant differences were observed in per cent bud opening per spike among different treatments in *Dendrobium* orchids cv. Sonia 17.

The cut spikes held in holding solution containing 75% flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose recorded maximum per cent bud opening per spike (86.25%) while, minimum per cent bud opening per spike was observed in control (fully opened flowers kept in water) (76.26%).

The 75% flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose showed maximum per cent bud opening per spike which might be due to the maintenance of a higher turgor value contributed to the anthesis of a larger number of flowers.

Number of unopened and abscised buds per spike (%)

The data pertaining to the effect of holding solutions and harvest stage on number of unopened and abscised buds per spike of *Dendrobium* orchids cv. Sonia 17 is presented in Table 2. The number of unopened and abscised buds per spike was calculated and recorded. Significant differences were observed in number of unopened and abscised buds per spike among different treatments in *Dendrobium* orchids cv. Sonia 17.

Among all the treatments significantly minimum unopened and abscised buds per spike was observed in cut spikes held in holding solution containing 75% flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose (15.37 %) while, maximum unopened and abscised buds per spike was observed in control (fully opened flowers kept in water) (24.27 %).

Based on results obtained, it may be concluded that minimum number of unopened abscised buds per spike was recorded maximum when 75% flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4 % sucrose.

The holding solution of 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose helped in supply of carbohydrates and prevents microbial load in holding solution resulted in less unopened and abscised buds per spike.

Vase life (days)

The data pertaining to the effect of holding solutions on vase life and optimization of harvest stage on *Dendrobium* orchids cv. Sonia 17 is presented in Table 2. The data was recorded from the time of keeping the flowers in vase until the first sign of wilting or fading of the 50% flower petals. Significant differences were observed in vase life among different treatments in *Dendrobium* orchids cv. Sonia 17.

Data revealed that among all the treatments, significantly maximum vase life was observed in cut spikes held in holding solution containing 75% flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose (31.52 days) while, minimum vase life was observed in control (fully opened flowers kept in water (15.06 days).

The enhanced vase life of *Dendrobium* cut spikes of 75% flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose can be attributed to continued and increased water uptake in the cut spikes, higher retention of fresh weight and high petal sugar. These conditions contributed to optimum continuation of the cell metabolism that facilitated cell growth and development, formation of cellular constituents and the liberation of energy for other cellular functions (Auty *et al.,* 2015 in *Dendrobium*).

Sucrose delayed the degradation of proteins, lipids and nucleic acids, as well as maintained the integrity of membranes and the structure and function of mitochondria. In addition, sucrose inhibited the production and action of ethylene, improved water balance and regulated stomatal closure, thus reduced transpirational loss and improved vase life. (Nowak *et al.,* 1991).

The effect of 8HQC in enhancing the vase life of cut flowers had been attributed to its antibacterial and antifungal property. Anti-ethylene characteristic of silver nitrate contributed towards delay in senescence and extended vase life in *Dendrobium* cut spikes as *Dendrobium* is an ethylene sensitive flower.

Organic acids like citric acid influenced the vase life of cut flowers as they are source of both carbon and energy for cells and are used in the respiratory cycle and some other biochemical pathway. Citric acid reduced bacterial population in holding solution and increased the water conductance in xylem of cut flowers (Van Doorn, 1997). The positive effect of citric acid on postharvest longevity of some cut flowers like lilium and tuberose was reported by Eidyan (2010) and Darandeh and Hadavi (2012) respectively.

Total microbial count (CFU/ml)

The data pertaining to the effect of holding solutions and harvest stage on microbial count of *Dendrobium* orchids cv. Sonia 17 is presented in Table 2. Dilute plant method was followed to measure Yeast and mould population. Significant differences were observed in microbial count among different treatments in *Dendrobium* orchids cv. Sonia 17.The cut spikes held in holding solution containing 75% flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose recorded minimum microbial count (20.70 CFU/ml) while, maximum microbial count was observed in control (fully opened flowers kept in water) (38.38 CFU/ml).

Based on results obtained, it may be concluded that minimum microbial count was recorded when 75% flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose. Bacteria or fungi or both, proliferate in the holding solution and clog the water conducting tissue eventually restricting the water absorption. 8HQC reduces the microbial growth and improves the water uptake and helps in maintaining the turgidity of cut flowers (Halevy and Mayak, 1974). Citric acid is an acidifier and acidic solution inhibits bacterial growth and proliferation, inhibits the growth of micro organisms, while these can alleviate water uptake and extend vase life (Bhattacharjee *et al.,* 1993). Silver nitrate reduced the severity of gray mold on rose and carnation by inhibiting ethylene action. This inhibition reduced the senescence of the flowers. The wide antimicrobial effect of silver nitrate is well-known, since Ag+ ions replaces the hydrogen cations (H+) of

sulfhydryl or thiol groups (- SH) on surface proteins in cell membranes of bacteria, which leads to loss of membrane integrity and causing cell death (Feng *et al.* 2000). $AgNO_3$ prevented microbial occlusion of xylem vessels in *Dendrobium*, thereby enhancing the water uptake and increasing longevity of flowers. Similar results were obtained by Khan *et al.* (2015) in *Dendrobium.*

Conclusion

Significant difference for physiological loss of weight (%), vase life (days), days for fading of first and last flower (days), percent bud opening per spike (%), number of unopened and abscised buds per spike (%), water uptake (ml), microbial count (CFU/ml) of *Dendrobium* flowers cv. sonia 17 in both harvesting stages (50% flowers open stage and 75% flowers open stage) was observed with the holding solutions. However, response of 75% flowers open per spike was better as compared to 50% flowers open per spike with respect to all the parameters in terms of post harvest quality and vase life.

Maximum water uptake was found in 75% flowers open stage of harvest as compared to 50% flowers open stage of harvest. A high level of turgidity is necessary for development of flower buds to full bloom maturity and for the continuation of normal metabolic activity in cut flowers (Rogers, 1962 and Mayak and Halevy, 1974). Turgidity is positively correlated with water uptake. In cut flowers after detachment from the plant rate of transpiration and respiration increases while absorption decreases. Thus, flower excision results in water loss in excess of water uptake leading to decline in stem water potential. Hence, to maintain turgidity continuous water uptake is essential. If the rate of water loss exceeds water uptake in the flower tissue, it experiences water stress. In less advanced stage initially water uptake is at slow rate as the surface for transpiration is less, but with the opening flower buds, surface of transpiration increases but it decreases with commencement of senescence stage as also indicated by Brahmankar *et al.* 2005 in golden Rod and Singh *et al.* (2003) in rose. Similar effects of harvesting stages on water uptake have been recorded in golden rod by Brahmankar *et al.* 2005 and in gladiolus by Singh *et al.* (2005). Fresh weight was directly influenced by water uptake in *Dendrobium* cut spikes. Weight gain in cut spikes occurs through water uptake while weight loss occurs due to continuous transpiration as well as respiration. Thus improved water uptake and low weight loss contributed by lower respirational loss of carbohydrate contributed to well retain fresh weight in 75% opening stage of *Dendrobium* cut spikes. Similar results have been reported by De and Barman (1998) in tuberose and Singh *et al.* (2005) in gladiolus and Brahmankar *et al.* (2005) in golden Rod. Trend of bud opening percentage per spike appeared to decreased with earliness in harvest stage. This decrease in bud opening phenomenon can be explained due to lack of carbohydrate accumulation in buds as earlier elucidated by Ketsa and Teerajaroenpunya (1990) in orchids. Waithaka *et al.* (2001) reported increase in accumulated carbohydrates content in opened florets of gladiolus as compared to unopened bud and increased carbohydrates further accompanied petal expansion in flower. Thus, higher carbohydrate accumulation in advanced harvest stage must have lead to more expansion of petals along with opening of flowers at slower rate. Similar findings of improved bud opening due to maintained water uptake and retained fresh weight have been earlier elucidated in rose (Madhubala *et al.,* 2008). Harvest stage had significant effect on unopened and abscised buds per spike (%). The minimum unopened and abscised buds per spike (%) was observed in 75% flowers open spike as compared to 50% flowers open spike. Lower accumulation of carbohydrate accompanied by low water uptake caused more abscission of unopened buds in spikes harvested at early stages (50%). Similar results have been reported in orchid (Ketsa and Boonrote, 1990) and in gladiolus (Singh *et al.,* 2007c). Harvest stage showed significant influence on vase life. The 75% flowers open stage of harvest showed maximum vase life as compared to 50% flowers open stage of harvest which might be due to higher water uptake and fresh weight retention in 75% flowers open stage of harvest. Similar effects of different harvest stages on vase life was observed in orchids by Ketsa and Kosonmethakul (2001), in tuberose by De and Barman (1998) and in rose by Singh *et al.* 2003.

Thus, improved water uptake, fresh weight retention and low electrolyte leakage contributed towards excellent post harvest flower quality in terms of high turgidity and freshness in *Dendrobium* cut spikes harvested at 75% flowers open stage and treated with holding solution combinations of 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose.

Table 1 : Effect of Holding solutions and harvest stage on Physiological loss of weight (%), Water uptake (ml), Days for fading of first flower (Days), Days for fading of last flower (Days) and Percent bud opening per spike (%) of Dendrobium Orchids cv. Sonia 17

Treatments	Physiological loss of weight (%)	Water uptake (ml)	Days for fading of First flower (Days)	Days for fading of Last flower (Days)	Percent bud opening per spike (%)
T_1: 50 % flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + 4% sucrose	65.00	5.42	14.55	39.63	81.25
T_2: 50 % flowers open spike treated with 8HQC (300 ppm) + citric acid (400 ppm) + 4% sucrose	61.46	6.08	14.73	41.43	82.18
T_3: 50 % flowers open spike treated with $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose	66.89	4.88	13.88	38.80	80.22
T_4: 50 % flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose	59.26	6.75	15.63	44.32	81.52
T_5: 75 % flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + 4% sucrose	55.84	7.35	15.60	45.93	82.85
T_6: 75 % flowers open spike treated with 8HQC (300 ppm) + citric acid (400 ppm) + 4% sucrose	51.50	8.72	17.82	49.45	84.32
T_7: 75 % flowers open spike treated with $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose	53.97	7.95	16.25	47.63	83.60
T_8: 75 % flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose	49.23	9.48	18.90	52.32	86.25
T_9: Control (Fully opened flowers kept in water)	75.30	4.25	9.66	32.62	76.26
Mean	**59.82**	**6.76**	**15.22**	**43.57**	**82.05**
SEm±	0.35	0.15	0.34	0.30	0.44
CD at 5%	1.15	0.47	1.01	0.90	1.37

Table 2 : Effect of Holding solutions and harvest stage on Number of unopened, abscised buds per spike (%), Vase life (Days) and Total microbial count (CFU/ml) of Dendrobium Orchids cv. Sonia 17

Treatments	No. of unopened, abscised buds per spike	Vase life (Days)	Total Microbial count (CFU/ml)
T_1: 50 % flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + 4% sucrose	19.35	25.12	29.07
T_2: 50 % flowers open spike treated with 8HQC (300 ppm) + citric acid (400 ppm) + 4% sucrose	19.10	26.15	27.52
T_3: 50 % flowers open spike treated with $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose	19.88	23.90	30.20
T_4: 50 % flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose	18.70	26.93	27.00
T_5: 75 % flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + 4% sucrose	17.65	28.18	25.18
T_6: 75 % flowers open spike treated with 8HQC (300 ppm) + citric acid (400 ppm) + 4% sucrose	15.75	29.78	22.33
T_7: 75 % flowers open spike treated with $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose	16.88	29.28	23.78
T_8: 75 % flowers open spike treated with 8HQC (300 ppm) + $AgNO_3$ (40 ppm) + citric acid (400 ppm) + 4% sucrose	15.37	31.52	20.70
T_9: Control (Fully opened flowers kept in water)	24.27	15.06	38.68
Mean	**18.55**	**26.21**	**25.72**
SEm±	0.31	0.30	0.25
CD at 5%	0.96	0.47	1.01

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