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Effect of Gamma Irradiation as Phytosanitary Treatment on Vase Life of White and Pink Carnation (*Dianthus caryophyllus* L.) Cut Flowers

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Abstract

Carnation (*Dianthus caryophyllus* L.) cut flower is commercially cultivated for its wide range of colours under protected cultivation in the poly houses of Telangana. A survey was conducted in the poly houses of Nalgonda and Suryapet districts during March, 2019 to identify major pest problem associated with carnation cut flower in which, bud borer, thrips and mites were identified as the major problem. Irradiation, a non chemical approach is used as one of the phytosanitary treatment for the control of quarantine insects. As it is important to verify the tolerance of cut flower to radiation, an experiment was conducted to study the effect of irradiation on the vase life of white and pink carnation cut flowers. The gamma irradiation at 150, 250, 350 and 450 Gy doses were evaluated on white and pink carnation at room temperature as experimental set I (27º ± 1ºC) and at refrigerated condition as experimental set II (4º C). The present study indicates that both white and pink carnations can tolerate different doses up to 450 Gy based on freshness score, relative fresh weight and volume uptake when stored under refrigerated condition up to 13 days and white carnations under room temperature up to 5 days. The pink carnation were tolerant up to 2 days only and started to show deterioration from 3rd day onwards at room temperature. The irradiated as well non irradiated pink carnation were found to be not suitable for storage at room temperature based on freshness score. The white carnation flowers responded well and performed better compared to pink carnation at room and refrigerated condition. The carnation cut flowers were toletant to 450 Gy dose irradiation and this dose is effective against most insects. Hence, irradiation can be used as a phytosanitary measure to control most of the quarantine significance pests associated with carnation. Another experiment to determine the effect of chemical holding / preservative solution on the vase life of carnation was conducted at Plant Biosecurity Division, National Institute of Plant Health Management, Hyderabad. The cut flowers were placed in different holding solutions at room temperature *viz*. T1: Sucrose (2%); T2: Citric acid (200 ppm); T3: Sucrose (2 %) + Citric acid (200 ppm); T4: Silver thio sulphate (150 ppm); T5: Silver thio sulphate (150 ppm) + Sucrose (2%); T6: Silver nitrate (150 ppm); T7: 8-Hydroxy quinolone sulphate (150 ppm) T8: Distilled water (control) and the treatments were analyzed based on relative fresh weight, freshness score and solution uptake. Based on the result it was found that citric acid - 200 ppm and sucrose (2%) + citric acid - 200 ppm was the best holding solution for white and pink carnation respectively and these preservative solutions helps to prolong the vase life of carnation cut flowers.

Keywords : Irradiation, Phytosanitary treatment, Carnation, Cut flower, Vase life, Survey, Insect

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FLORICULTURE and ornamental industry has emerged as a profitable agri-business in India which mainly consists of cut flowers, cut foliage and ornamental plants (APEDA, 2019). The diverse climatic conditions of India provides opportunities for production of major cut flowers such as rose, carnation, chrysanthemum, gerbera, orchid and lilies. Among the cut flowers, carnation is the most popular commercial one in the International trade due to its wide range of colours and excellent keeping quality. This cut flower is associated with symbolism and hence used to express love, gratitude, admiration and fascination.

Carnation (*Dianthus caryophyllus* L.) belongs to family Caryophyllaceae is one of the leading high valued cut flower in the world and it ranks within top ten cut flower traded in the world floriculture market. It is available in bright colours ranging from pink, white, red, yellow and purple. Carnation is a major cut flower in the European market and European Union imported carnations worth of 211 million Euros in 2015 (CBI-EU, 2019). India exports cut flowers such as rose, carnation, orchids, chrysanthemum and lilies to many countries and during 2018-19, it exported carnation cut flowers worth of 0.24 million US$ to United States of America, United Kingdom, United Arab Emirates, Oman and other countries (DGFT, 2019).

Carnation is commercially grown under protected cultivation in green/poly house which is often subjected to attack by various insects and diseases. The exportable cut flowers act as a pathway for introduction and spread of insects and other pests into importing countries due to its complex nature which provide hiding spots for insects. Hence, phytosanitary treatment as part of phytosanitary measure is essential for cut flowers intended for export/import as a pest risk management option.

Radiation is effective in killing or sterilizing organisms which contaminate the commodities. It can be used as an effective non-chemical alternative quarantine treatment to methyl bromide fumigation for treating cut flowers and ornamental foliages. It is proved to be effective for disinfesting perishable products such as fruits, vegetables and cut flowers. The use of radiation for post-harvest and quarantine commodity control is cited by the Environmental Protection Agency of the United States (EPA, 1996).

Radiation would provide an excellent phyto saintary treatment by not only controlling the insects but also it leaves no residue after treatment in the flowers/foliages. But the information on the dose which does not damage the carnation cut flowers in India is scanty. Considering the importance, the present study was undertaken to identify the major pests associated with carnation cut flower, to study the effect of irradiation on the vase life of white and pink carnation cut flowers and to evaluate the performance of these carnation cutflowers under various holding solutions.

MATERIAL AND METHODS

Survey for Identification of Major Pests

Survey was conducted in carnation cultivating areas of Nalgonda and Suryapet districts of Telangana state during March, 2019. The different colours of carnation were grown in raised bed under protected condition in the poly houses to maintain the quality and yield. As carnation crop has the tendency to bend, staking was done to support the plant. The survey was conducted to identify the major insects and diseases associated with carnation cut flower.

Irradiation Studies of Carnation Cut Flower

In order to study the tolerance of carnation (*Dianthus caryophyllus* L.) cut flower to irradiation, the white and pink colour cut flowers along with stem were obtained from local market. The flowers were cut approximately 15 cm and placed in tap water for 12 hours before irradiation. Later, the flowers were irradiated at 150, 250, 350 and 450 Gy doses. The Gamma GC 5000 Category-I gamma irradiator located at Prof. Jayashankar Telangana State Agricultural University operating under the technical supervision of MFPI - Quality Control Laboratory, Hyderabad was used for irradiation studies. After irradiation, the stem of carnation were placed in

distilled water at room temperature (27±2ºC) as experimental set I and at refrigerated conditions (4ºC) as experimental set II. The observation on 2 major parameters relative fresh weight and freshness score were taken at regular intervals. Water uptake was measured by subtracting the water at the last day in flower vase from the initial water of the flower vase.

Studies on Vase Life of Carnation Cut Flower

The experiment to find out the best appropriate chemical preservative / holding solution for extending the vase-life of white and pink carnation cut flowers were conducted at Plant Biosecurity Division, NIPHM. The preservative solutions were used alone or in combinations as follows: T1 : Sucrose (2 %); T2 : Citric acid (200 ppm); T3 : Sucrose (2 %) + Citric acid (200 ppm); T4 : Silver thio sulphate (150 ppm); T5 : Silver thio sulphate (150 ppm) + Sucrose (2 %); T6 : Silver nitrate (150 ppm), T7 : 8-Hydroxy quinoline sulphate (150 ppm) and T8 : distilled water (control). The observation on relative fresh weight and freshness score were taken on different days intervals. Solution uptake was measured by subtracting the solution at the last day in flower vase from the initial solution of the flower vase.

Results and Discussion

Survey for Identification of Major Pest

Carnation, the imporant cut flower in International trade is cultivated commercially in many countries for its breath taking colours and appearance. Many states in India too started to cultivate carnations on commercial scale for domestic as well as export purpose.

Survey was conducted in carnation growing poly houses of Nalgonda and Suryapet districts of Telangana state during March, 2019. The farmers cultivated white, pink and red colour carnation in a single poly house under protected cultivation as there is a huge market demand exists for these colours through out the year. During survey, thrips, bud borers (*Spodoptera* and *Helicoverpa*) and mites were identified as major insect pests associated with carnation. The thrips were observed not only on leaves but also on carnation flower. The feeding damage of thrips on flowers made streaks which ultimately reduced the quality of the flower. The bud borer larva bored into growing buds and fed on petals; it also attacked the opened flower petals which made them damaged and unmarketable. The bud borer *Helicoverpa armigera* (Hubner) was considered the most important pest causing serious damage to the flowers of carnation (Multani and Sohi, 2002). The pests such as thrips, gram pod borer, mites and aphids were found to be infesting the carnation growing in the hilly region of West Bengal (Pal and Sarkar, 2009).

Irradiation Studies of Carnation

In order to know the irradiation dose that does not affect the quality of carnation, the white and pink carnation were irradiated at 150, 250, 350 and 450 Gy doses. The irradiated and non-irradiated (control) cut flowers were kept at room temperature (27±2ºC) as experimental set - I as well as refrigerated condition (4ºC) as experimental set - II and the physical changes were monitored for relative fresh weight and freshness score at different day intervals.

Relative Fresh Weight (RFW)

The changes in Relative Fresh Weight (RFW) of white and pink carnation cut flowers showed similar trends for both irradiated and non irradiated treatments at room temperature but varied under refrigerated condition. The relative fresh weight was more in all the irradiated doses compared to non irradiated control throughout the experiment period at room temperature in both white and pink carnation cut flowers (Fig. 1.1 and Fig. 1.2). Interestingly, the relative fresh weight of white carnation was more compared to pink in all irradiated doses and non irradiated control at room temperature. There was no significant difference among all the treatments, but the RFW changes were varied among the irradiated dose. In both white and pink carnation, the flowers irradiated at 450 Gy showed more RFW than other irradiated doses and it was 13.6 per cent and 8.93 per cent; 31.96 per cent and 15.37 per cent more compared to control 5 DAT and 9 DAT, respectively.

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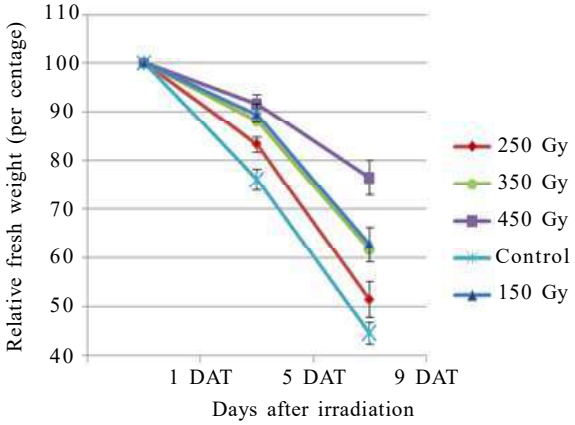


Fig 1.1 : Relative fresh weight of white carnation at room temperature

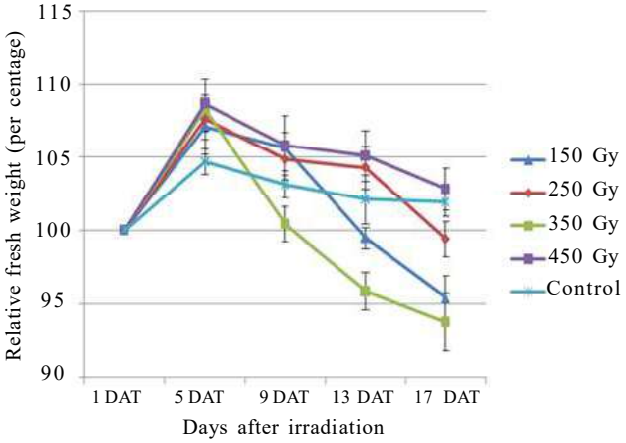


Fig 1.3 : Relative fresh weight of whitw carnation at refrigerated condition

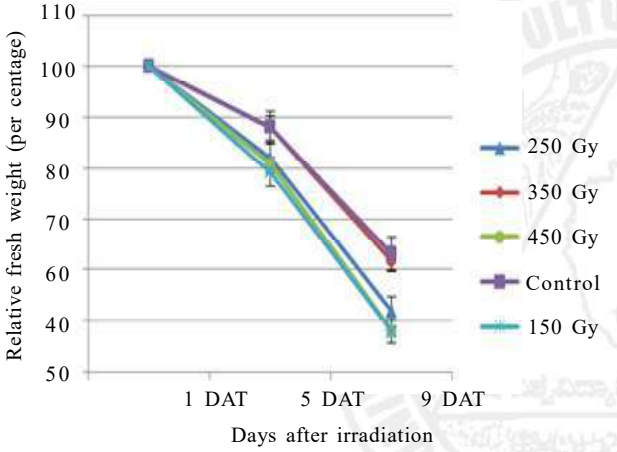


Fig 1.2 : Relative fresh weight of pink carnation at room temperature

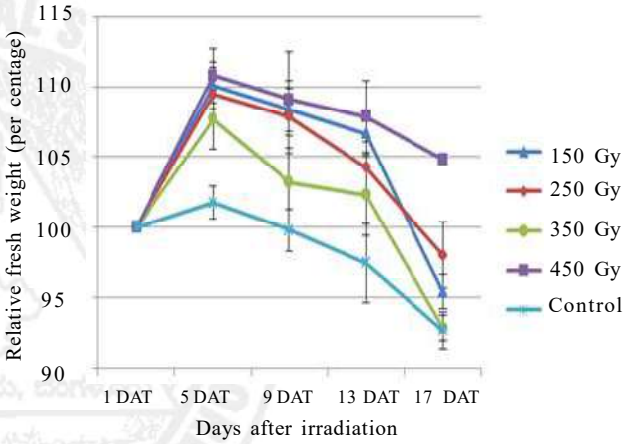


Fig 1.4 : Relative fresh weight of pink carnation at refrigerated condition

Fig. 1 : Effect of irradiation on relative fresh weight of white and pink carnation at room temperature and refrigerated condition

In experimental set - II where the cut flowers kept under refrigerated condition, the RFW was more than 100 in all the irradiated doses and non irradiated control and it was more in 450 Gy both in white and pink cut flowers compared to other treatments (Fig. 1.3 and Fig. 1.4). There was an increase in RFW up to 5 DAT but, it was dramatically reduced after 5 days except 450 Gy in which gradual reduction was observed. Under refrigerated condition also, there was no significant difference among all the treatments, but RFW varied at different days for different doses. In white carnation, 450 Gy and 250 Gy irradiated cut flowers showed more RFW compared to control up to 13 DAT but in case of pink carnation, RFW was more in all the irradiated doses compared to non irradiated control.

Freshness Score

During the period of evaluation, the white carnation flowers were more fresh compared to pink carnation. In experimental set - I at room temperature, maximum freshness score of 2.5 was observed at 5 DAT in 350 and 450 Gy and less than 2.5 was observed in 150, 250 Gy and control in white carnation. Interestingly, the freshness score was less than 2.5 in all the treatments as well as control at 5 DAT in pink carnation. Under refrigerated condition, both white and pink carnation flowers were fresh

and the freshness was steadily reduced up to 13 DAT wherein the score was more than 3.3 for treatments as well as control. In both the experiments at room temperatue and at refrigerated condition, the freshness score of white and pink carnation was more in irradiated flowers compared to non irradiated control.

Water Uptake

In both experimental sets, set - I (room temperature) and set - II (refrigerated condition), the water uptake was more in white carnation compared to pink except 450 Gy and non irradiated control at refrigerated condition. The water uptake at room temperature in white carnation was ranged from 45 to 52 ml where as it ranged from 38 to 45 ml in pink carnation. The water uptake was more in 450 Gy which was 52 and 45 ml respectively for white and pink carnation at room temperature (Fig. 3). But, the differences among doses for water uptake were trivial for carnation kept at refrigerated condition.

The result of the above study indicated that white carnation flowers were tolerant to irradiation dose of 450 Gy based on relative fresh weight, freshness score and water uptake at room temperature up to 5

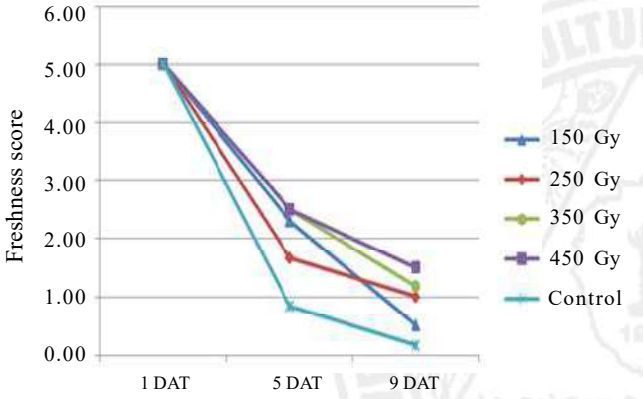


Fig. 2.1 : Freshness score of white carnation at room temperature

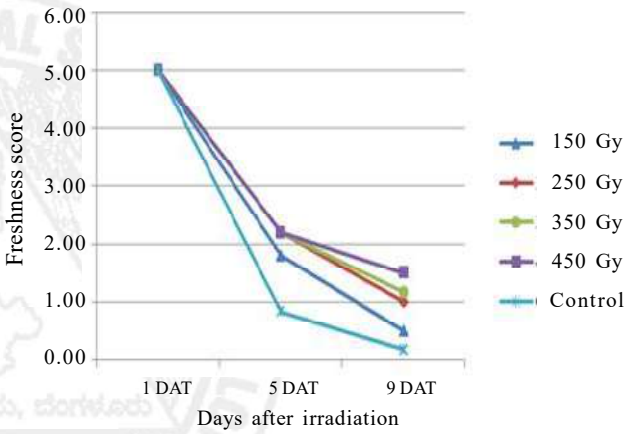


Fig. 2.3 : Freshness score of pink carnation at room temperature

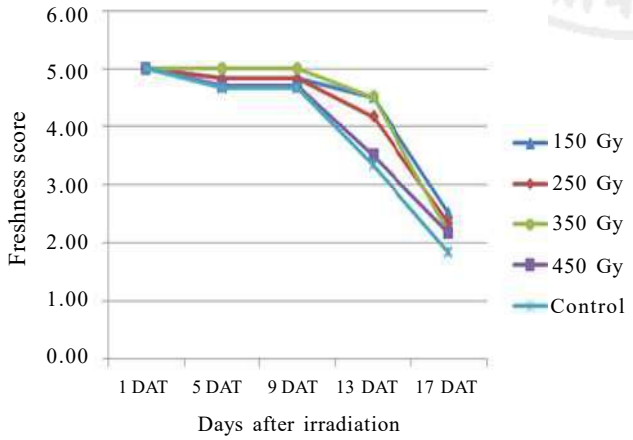


Fig. 2.2 - Freshness score of white carnation at refrigerated condition

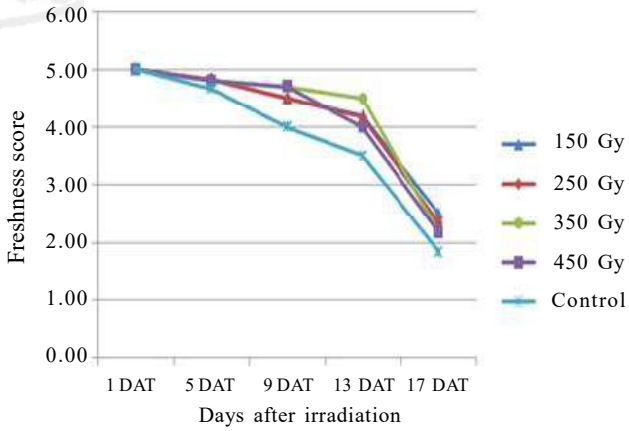


Fig. 2.4 - Freshness score of pink carnation at refrigerated condition

Fig. 2 : Effect of irradiation on freshness score of white and pink carnation at room temperature and refrigerated condition

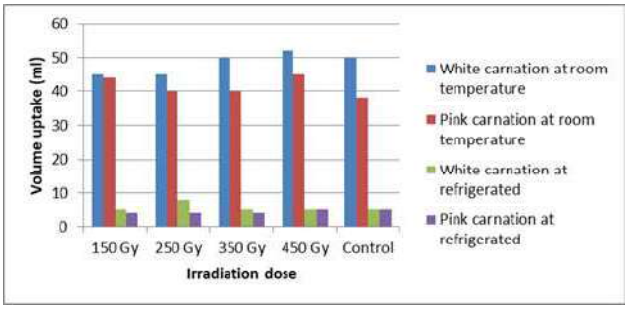


Fig. 3 : Effect of irradiation on water uptake of white and pink carnations at room temperature and refrigerated condition

DAT. The pink carnation were tolerant up to 2 days only and started to show deterioration from 3rd day onwards at room temperature. The irradiated as well non irradiated pink carnation were found to be not suitable for storage at room temperature based on freshness score. However, when stored at refrigerated condition, the white and pink carnation cut flowers were tolerant to irradiation dose of 450 Gy based on the above parameters. The white flowers were tolerant up to 5 days at room temperature in experimental set - I, but in experimental set - II at refrigerated condition, both white and pink carnation flowers were fresh even up to 13 days (Fig. 4).

Ionizing radiation is used as a phytosanitary treatment to disinfest pests in traded commodities. In recent years, irradiation has emerged as a viable alternative phytosanitary treatment to methyl bromide. Many countries use radiation for a growing number of fruits and vegetables against quarantine insects. The United States of America approved radiation as a phytosanitary treatment for import of regulated article such as fruits, vegetables, cut flowers and foliage (USDA APHIS, 2019).

Fig. 4. Effect of irradiation on white and pink carnations at room temperature and refrigerated condition on 5 DAT

The present study indicates that both white and pink carnations can tolerate different doses up to 450 Gy based on freshness score, relative fresh weight and volume uptake when stored under refrigerated condition up to 13 days and white carnations under room temperature up to 5 days. The white carnation flowers responded well and performed better compared to pink carnation at room and refrigerated condition. In Japan, Hayashi *et al*. (1999) studied the effect of electron beams on cutflpwers and reported that carnation were resistant up to 400 Gy along with other cut flowers such as Dendrobium, Gladiolus and Tulip, etc.

Carnation when irradiated by gamma-radiation in the developed flowering stage were tolerated doses up to 900 Gy (Kikuchi *et al*., 1999). Tran *et al*., 2016 studied the tolerance and quality of irradiated carnation and chrysanthemum using electron beam ≥ 300 Gy to provide appropriate recommendations for commercial application and found that cut carnation were more tolerant to electron beam radiation than cut chrysanthemum. They also observed that white chrysanthemum was more sensitive to radiation than yellow one and found that this dose is effective quarantine dose for red mite infesting on cut flowers.

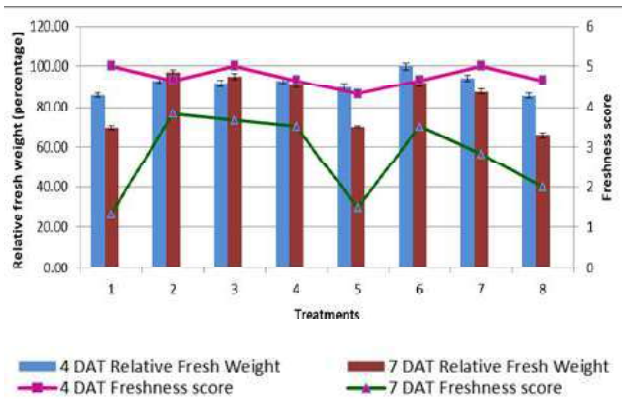
Vase Life Studies using Holding/Preservative Solutions

The experiment using different holding / preservative solutions to find out the best suitable one for the vase life of white and pink carnation was conducted at room temperature. The data on relative fresh weight, freshness score and solution uptake were taken on different days intervals and the results were presented here.

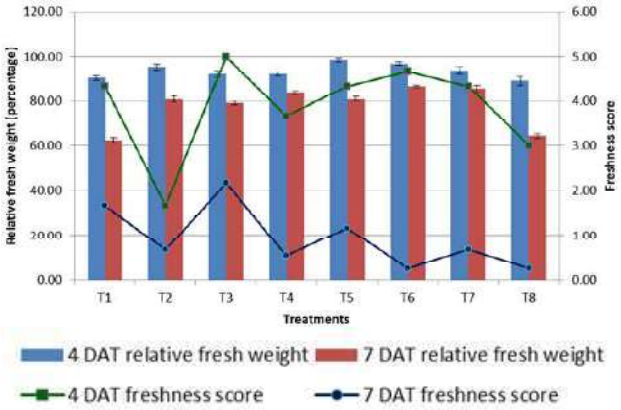
Relative Fresh Weight

The data pertaining to the effect of holding/ preservative solution on relative fresh weight of white and pink carnation cut flowers at room temperature is presented in Fig. 5 (Fig. 5.1 and Fig. 5.2).

Based on the results, there was no significant differences between the treatments and the control



5.1: Relative fresh weight and freshness score of white carnation



5.2 : Relative fresh weight and freshness score of pink carnation

Fig. 5 : Effect of different holding solutions on relative fresh weight and freshness score of white and pink carnation at room temperature

on 4 DAT and 7 DAT in both white and pink carnation.

In white carnation, distinct variation was observed among treatments as there was an increase in RFW on 7 DAT in citric acid, sucrose + citric acid treatments but in other treatments and control, decrease in RFW was observed. In case of pink carnation, less variation was observed among the treatments and there was a decrease in RFW in all treatments as well control on 7 DAT. In pink carnation, the RFW was more in silver nitrate, 8- hydroxy quinoline sulphate and silver thio sulphate compared to other treatments and control on 7 DAT.

Freshness Score

During the period of evaluation, less variation was observed in the freshness score of white carnation on 4 DAT but, distinct difference was observed on 7 DAT among the treatments in such a way that citric acid, sucrose + citric acid, silver thio sulphate, silver nitrate remained fresh on the other hand sucrose, silver thio sulphate + sucrose and distilled water (control) showed shrinking of the flower petals and less than 2.5 freshness score. But, in pink carnation, distinct variation was observed even on 4 DAT, the highest freshness score of 5 was witnessed in sucrose + citric acid combination but in citric acid alone the freshness score was less than 2. Interestingly, on 7 DAT, the freshness score was less than 2 in all the treatments as well distilled water (control).

Solution Uptake

The solution uptake was more in white carnation than in pink carnation and it varied among the different holding / preservative solutions. In white carnation, maximum solution uptake was observed in flowers placed in silver thio sulphate (71.67 ml) followed by citric acid (65 ml) whereas minimum uptake was from silver nitrate -150 ppm (5 ml) (Fig. 6). But in pink carnation, maximum solution uptake was in citric acid -150 ppm (41.67 ml) followed by silver nitrate -150 ppm (35 ml) and 8-hydroxy quinolone sulphate - 150 ppm (35 ml).

From this experiment on preservative solution for vase life based on the above parameters, it was found

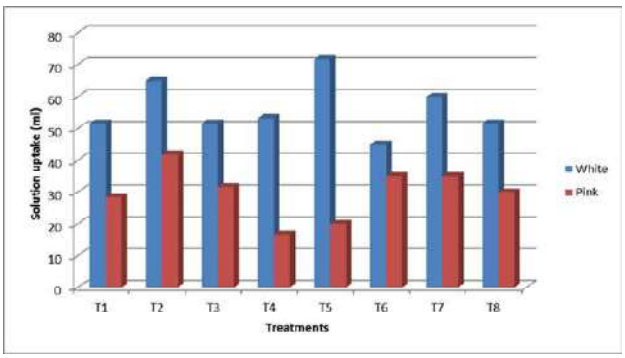


Fig. 6. Solution uptake of white and pink carnation placed in different holding solutions

that citric acid - 200 ppm was the best holding solution for white carnation followed by 8-Hydroxy quinoline sulphate (150 ppm) and silver nitrate (150 ppm). These solutions can prolong the vase life upto 7 days at room temperature in white carnation. Interestingly, the sucrose (2%) + citric acid - 200 ppm combination treatment was giving best results on 4 DAT in pink carnation followed by silver nitrate - 150 ppm and silver thio sulphate - 150 ppm.

The results of irradiation studies and vase life holding solutions clearly indicated that the white carnation cut flowers was found to be more promising compared to pink carnation. The vase-life is one of the most important characteristics in determining the quality, satisfying consumer preferences and the commercial value of cut flowers. The post-harvest life of cut flowers can be extended using preservative solutions for increasing the vase-life. In the present study, citric acid - 200 ppm and sucrose (2%) + citric acid - 200 ppm combination increased the vase life of white and pink carnation cut flowers up to 7 and 4 days respectively and these can be used as the best holding solution for white and pink carnation respectively. Citric acid is known as an acidifier and it reduces the incidence of microorganism in the vase solution. Citric acid alone and in combination with sucrose increased the vase life of cut flowers such as Tubrose, Rose and Cosmos. In case of rose cut flower, Shirin and Mohsen (2011) studied the effect of chemical treatments and sucrose on vase life of 3 cultivars, namely 'Bouing', 'Creamly' and 'Sena' and found that citric acid + sucrose was the best and safest treatment for 'Bouing' and 'Creamly' cultivars and silver thiosulphate + sucrose for the cultivar 'Sena'. Based on the results of present study as well the study done by Shirin and Mohsen (2011), it was found that the preservation solutions can extend the cut flowers longevity and improve post harvest flowers quality, but their effects varies depending on the cultivar. Citric acid increased the vase life of Tuberose (*Polianthes tuberosa* L.) and the longest mean vase life of 7 days was observed when the flowers were placed in citric acid prepared in sterile distilled water (Jowkar and Salehi, 2005). Ruby Patel *et al*., 2016 studied the shelf life of *Cosmos sulphreus* cut flower with various chemical preservatives and found that citric acid + sucrose increased shelf life up to 5 days.

In general, variation in vase life was observed among different carnation cultivars. In the present study also, white carnation vase life was more compared to pink in both radiation and vase life studies using preservative solutions. Wu *et al*., 1991 found that flowers of 'Sandra' and 'Chinera' cultivars of carnation last about 14 days as those of 7 days in 'White Sim' cultivar. From this study, it was found that Carnation cut flowers were tolerant to irradiation and it can be used as a phytosanitary measure. Further, research is necessary to evaluate scaling up of irradiation as phytosanitary treatment at variety level for commercial application.

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