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Effect of pre-harvest spray and storage conditions on shelf life of marigold cv. 'Pusa Narangi Gainda

Prashant Sharma, Bharati Kashyap, Shabnam Pangtu and Anshul Kumar

Abstract
An experiment was conducted to study the effect of different pre harvest sprays, storage conditions and storage durations on marigold cv. 'Pusa Narangi Gainda'. Studies included three pre-harvest spray of BA @ 50 ppm, jeevamrut @ 10 ppm and distilled water (control) on standing crop and harvested flowers were packed in cardboard boxes and stored under cold storage (4 ºC) and room temperature for five different storage durations (1, 2, 3, 4 and 5 days). Study revealed that shelf life was increased in both the pre-harvest sprays over control but BA 50 ppm resulted in maximum shelf life (3.65 days) with minimum weight change (8.27%), minimum spoilage (11.49%) and maximum moisture content (84.81%). Among storage durations maximum shelf life (5.33 days) was observed under one day storage and minimum shelf life (1.17 days) was observed when the flowers were stored for five days. When storage conditions were analysed, better shelf life (3.42 days) was observed under refrigerated conditions when compared to room temperature (2.40 days). Flowers sprayed with BA 50 ppm and stored under refrigerated conditions for 1 day, maximum shelf life of 6 days was recorded and thus can be recommended for better post-harvest life of marigold.

Keywords: Marigold, BA (Benzyl Adenine), jeevamrut, ambient storage, refrigerated storage, storage durations, storage conditions

Introduction
Marigold (*Tagetes erecta*) is one of the most important loose flower crop grown commercially in different parts of India especially in the plains. It is a short duration, free blooming crop belonging to family Asteraceae and is native to Central and South America especially Mexico. Area under marigold flower production in India is 55,890 hectares (Anonymous 2015) [1]. Flowers of marigold are sold in market as loose flowers or after making garlands. Marigold known for its multi-ferous and diverse germplasm is associated with festive occasions, marriages, religious ceremonies and social functions. The flower is endured with a wide spectrum of attractive colours, shape and size, having good keeping quality. The high demand of the marigold flowers in the market during festival seasons from Navratras to Dussehra, Diwali and New Year has made this a farmer friendly crop.

The use of plant growth regulators has brought a sort of revolution in the floriculture industry. Many beneficial effects of different plant growth regulators have been reported on different horticultural crops including control of growth and flowering in many floral crops to produce high quality flowers (Sridhar, 2006) [14]. BA is basically a cytokinin and cytokinin treatments have been reported to delay leaf senescence and improve the keeping quality of many cut flowers (Mutui *et al.* 2001) [9]. Cytokinins have also been reported to promote chloroplast development and chlorophyll synthesis. BA is reported to increase the longevity of flower (Serek and Andersen, 1993) [12].

Besides this organic treatments also plays an important role in enchancing the growth and quality parameters. Jeevamrut is an organic liquid manure which is prepared by using the constituents cow dung, cow urine, jaggery, flour of gram, live/forest soil and mixing them properly. Foliar application of jeevamrut along with FYM and vermicompost enhanced the growth, yield and quality components in different crops (Janbhare *et al.* 2013) [7].

Different storage conditions affects shelf life of produce. Proper storage condition enhance shelf life by preserving freshness of the produce along with quality (Jadhav *et al*., 2018) [16]. Refrigerated storages extends the post-harvest life of flowers and thus the marketing potential of the flowers is increased. Temperature and storage duration affects the shelf life and quality of flowers (Cevallos and Reid, 2001) [3].

The present investigation was therefore carried out to find out proper intervention for enhancing shelf life of marigold, keeping in view the other qualitative characters.

Materials and Method

Study on effect of pre-harvest spray and storage conditions on shelf life of marigold cv. 'Pusa Narangi Gainda' was carried out in the Post-Harvest Laboratory of Department of Floriculture and Landscape Architecture at Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan during 2016-2017. The crop was grown in the experimental farm of the department, which is situated in the hilly areas of Western Himalayas at an altitude of 1276 m above mean sea level having latitude of 30° 52'2" North and longitude 70° 11' 30" East. The climate of area is typically semi temperate. For raising the marigold nursery, beds of 1.0 x 1.0 m were prepared thoroughly. After preparing nursery beds, the seeds of marigold cv. 'Pusa Narangi Gainda' were sown in the beds. The nursery beds were covered with soil, mixed with compost to ensure proper germination. Seedlings were regularly watered and timely plant protection measures were taken up. After the preparation of experimental plots (1.0 x 1.0 m) the healthy and uniform seedlings of twenty five to thirty days old were transplanted in the main field at 4 leaf stage during evening hours. Light irrigation was given after transplanting for better establishment of seedlings in the main field. The crop was grown following recommended cultural practices like weeding, hoeing, irrigation, fertilization, spraying against insect-pests and diseases, pinching, disbudding, de-shooting, staking etc. Solution of BA and Jeevamrut was prepared and sprayed on flowers 24 hours before harvesting. In control, the flowers were sprayed with distilled water. Flowers were harvested at standard stage i.e. fully opened flowers and were kept in cardboard boxes (37.5x16.4x12.5 cm) lined with polyethylene and sealed from the top. These boxes were kept under two storage conditions i.e. cold storage (4 °C) and at prevailing room temperature for various durations (1, 2, 3, 4 and 5 days). Cardboard boxes were taken out from storage after each duration and different observations were recorded. Weight change was recorded by taking the initial weight of 10 flowers immediately after harvesting and final weight was recorded after removing flowers from different storage conditions at different durations using the following formula:

$$\text{Weight change (\%)} = \{(\text{Initial weight-Final weight})/\text{Initial weight}\} \times 100$$

Shelf life was calculated after completing the particular treatment and then noting the number of days the flowers remained fresh at room temperature. Spoilage percent is calculated by taking observations from flowers kept at different storage conditions at different intervals using formula:

$$\text{Spoilage (\%)} = (\text{Number of spoiled flowers/total number of flowers}) \times 100$$

After removing flowers from storage conditions at different durations, moisture content of the flowers is calculed as:

$$\text{Moisture content (\%)} = \{(\text{Final weight-Dry weight})/\text{Final weight}\} \times 100$$

The data recorded on various parameters was analyzed for CRD (factorial) design as suggested by Panse and Sukhatme (2000) by using MS-Excel and OPSTAT.

Results and Discussion

Weight loss (%)

In table 1a, among different pre-harvest sprays, minimum weight loss (8.27%) was reported with BA 50 ppm application, however maximum weight loss (9.97%) was observed in control. This may be due to the fact that benzyl adenine reduces senescence, rate of respiration and ethylene production. The results obtained in the present investigation are in close conformity with those of Asil and Karimi (2010) [2] while working on eustoma cut flowers.

Among storage duration minimum loss in weight was observed when the flowers were taken out after one day storage (5.68%) and maximum weight loss was observed when the flowers were taken out after five days storage (13.79%). Flower deterioration is a continuous process and keep on increase with increasing time duration.

In case of storage conditions less weight loss was observed in cold storage (6.81%) as compared to room temperature (11.59%). Low temperature during storage slows down rate of respiration and other metabolic processes leading to less weight loss and slower deterioration (Cevallos and Reid, 2001; Shahri *et al*., 2009) [3, 13]. Minimum weight loss (5.36%) was observed when flowers were treated with BA 50 ppm and stored for one day, while studying interaction effect of foliar spray and storage duration. In contrast, maximum weight loss (14.88%) was observed when flowers sprayed with control distilled water (control) were kept for five days storage.

Interaction between storage duration and storage conditions indicates that minimum weight loss (4.46%) was observed when the flowers were stored for one day in cold store. Maximum weight loss (17.90%) was observed when the flowers were stored for five days at room temperature. Flowers sprayed with BA 50 ppm and stored under refrigerated conditions were recorded with minimum weight loss (6.14%), while maximum weight loss (12.55%) was observed when flowers sprayed with the distilled water were kept under room temperature conditions.

In table 1b, minimum weight loss (4.30%) occurred when the flowers sprayed with BA 50 ppm were stored for one day under refrigerated conditions, which was found statistically at par with flowers sprayed with Jeevamrut (4.40%) under refrigerated conditions. In contrast, maximum weight loss (19.20%) was observed under room temperature conditions when flowers were sprayed with distilled water and stored for five days.

Table 1a: Effect of pre-harvest treatments and storage on weight loss (%) of marigold flowers after storage

Pre- harvest spray Treatments (T)	Storage durations (D)					Mean	Storage conditions(C)	
	1 Day	2 days	3 days	4 Days	5 days		Cold Storage (4 °C)	Room temperature
BA (50 ppm)	5.36	6.39	7.89	9.58	12.15	8.27	6.14	10.40
Jeevamrut	5.66	6.91	8.89	10.92	14.35	9.35	6.89	11.80
Control (distilled water)	6.01	7.52	9.67	11.79	14.88	9.97	7.39	12.55
Mean	5.68	6.94	8.82	10.76	13.79		6.81	11.59
Storage conditions						CD 0.05 for T: 0.11 D x T: 0.24 D: 0.14 C x D: 0.19 C: 0.08 C X T: 0.15		
Cold Storage (4 °C)	4.46	5.36	6.52	8.04	9.68			
Room temperature	6.90	8.52	11.12	13.49	17.90			

Table 1b: Interaction effect of pre-harvest spray treatments (T) × Storage condition © × Storage duration (D) on weight loss (%) of marigold flower after storage

Pre- harvest spray Treatments (T)	Storage conditions (C)									
	Cold Storage					Room temperature				
	Storage duration (D)					Storage duration (D)				
	1 day	2 days	3 days	4 days	5 days	1 day	2 days	3 days	4 days	5 days
BA 50ppm	4.30	4.88	5.94	7.09	8.52	6.43	7.91	9.85	12.06	15.78
Jeevamrut	4.40	5.31	6.60	8.20	9.97	6.93	8.51	1.18	13.65	18.73
Control (distilled water)	4.68	5.91	7.01	8.83	10.56	7.35	9.14	12.34	14.76	19.20
$CD_{0.05}$ for T x D x C: 0.34										

Shelf life: In table 2a, pre-harvest spray of BA 50 ppm resulted in maximum shelf life (3.67 days), however, minimum shelf life (2.33 days) was obtained with the application of distilled water. Better shelf life was might be due to the property of BA to prevent the increase in the ethylene, O^{2-}, and H_2O_2 production and to increase the antioxidant enzyme activity measured in petals. Autocatalytic ethylene production is also inhibited by BA (Huang and Chen, 2002; Han and Miller, 2003) [6, 5]. Storage duration of one day resulted into maximum shelf life (4.28 days) and minimum shelf life (1.16 days) was observed when the flowers were stored for five days. Flowers stored under refrigerated conditions showed better shelf life (3.42 days) in comparison to room temperature (2.40 days). This might be due to the restricted physiological activities due to low temperature, which leads to reduction in the respiration rate. The use of refrigeration for storage of flowers is very important because it reduces water loss, senescence, infections caused by bacteria and fungi, thus extending the shelf- life of flowers during the storage period (Da Silva Vieira *et al*. 2012) [4].

Interaction between storage duration and pre-harvest spray treatments revealed that maximum shelf life (5.33 days) was observed when the flowers were sprayed with the BA 50 ppm and stored for one day. In contrast, minimum shelf life (1.17 day) was observed when flowers sprayed with distilled water were kept for five day storage.

Combined effect of storage condition and storage duration indicates that maximum shelf life (4.67 days) was observed when flowers were stored for one day under refrigerated conditions and minimum shelf life (0.67 days) was observed in flowers stored under room temperature for five days.

Flowers sprayed with BA 50 ppm and stored under refrigerated conditions maximizes shelf life (4.33 days). In contrast, minimum shelf life (1.93 days) was found when the flowers were sprayed with distilled water and stored at room temperature.

Flowers sprayed with BA 50 ppm and stored for one day under cold storage conditions resulted into maximum shelf life (6 days). In contrast minimum shelf life (0.33 days) was observed when the flowers were sprayed with distilled water and stored for five days under room temperature conditions (Table 2b).

Table 2a: Effect of pre-harvest spray treatments and storage on shelf life of marigold flowers

Pre-harvest spray Treatments (T)	Storage durations (D)					Mean	Storage conditions(C)	
	1 day	2 days	3 days	4 days	5 days		Cold Storage (4 °C)	Room temperature
BA (50 ppm)	5.33	4.50	3.67	2.83	2.00	3.67	4.33	3.00
Jeevamrut	4.00	3.33	2.67	2.17	1.50	2.73	3.20	2.27
Control (distilled water)	3.50	2.83	2.33	1.83	1.17	2.33	2.73	1.93
Mean	4.28	3.56	2.89	2.28	1.16		3.42	2.40
Storage conditions						CD 0.05 for T: 0.06 D x T: 0.13 D: 0.08 C x D: 0.11 C: 0.05 C X T: 0.08		
Cold Storage (4°C)	4.67	3.89	3.22	2.89	2.44			
Room temperature	3.89	3.22	2.56	1.67	0.67			

Table 2b: Interaction effect of pre-harvest spray treatment (T) × Storage condition (C) × Storage duration (D) on shelf life of marigold flowers.

Pre-harvest spray Treatments (T)	Storage conditions									
	Cold Storage					Room temperature				
	Storage duration (D)					Storage duration (D)				
	1 day	2 days	3 days	4 days	5 days	1 day	2 days	3 days	4 days	5 days
BA 50 ppm	6.00	5.00	4.00	3.67	3.00	4.67	4.00	3.33	2.00	1.00
Jeevamrut	4.33	3.67	3.00	2.67	2.33	3.67	3.00	2.33	1.67	0.67
Control (distilled water)	3.67	3.00	2.67	2.33	2.00	3.33	2.67	2.00	1.33	0.33
$CD_{0.05}$ for T x D x C: 0.19										

Moisture content (%)

Maximum moisture content (84.81%) was observed in flowers sprayed with pre-harvest spray of BA 50 ppm, however minimum moisture content was obtained in flowers sprayed with the distilled water (79.40%) (Table 3a). This might be due to the inhibition of the senescence and decrease in the rate of respiration by benzyl adenine which leads to minimum spoilage in flowers and decrease in the loss of moisture from the flowers owing to decrease in the respiration rate. These results are in agreement Malikshah (2017) [8].

Flowers stored for one day showed the maximum moisture content (88.85%), while minimum moisture content (75.50%) was observed in flowers which were stored for five days. Result obtained for different storage durations shows, minimum weight loss, maximum moisture content and minimum spoilage was obtained in day one storage. Similar results were obtained by Nagaraja *et al.* (1999) [10] who noticed the same trend on the tuberose flowers treated with BA up to day five.

When storage conditions were taken under consideration, flowers stored under refrigerated condition was observed with the greater moisture content (84.02%) than the flowers which were stored at room temperature (80.49%). This might be due to the decreased respiration rate at low temperature which results in reduction in the loss of moisture.

Among interaction effect, flowers sprayed with BA 50 ppm and stored for one day results into maximum moisture content (91.38%) in contrast to flowers sprayed with the distilled water and stored for the five days where minimum moisture content (72.17%) was recorded.

Interaction between storage durations and storage conditions indicates that maximum moisture content (90.26%) was obtained when the flowers were stored for one day under refrigerated conditions. On the other hand minimum moisture content (73.78%) was observed when the flowers were stored for five days under room temperature.

Flowers sprayed with BA 50 ppm as pre-harvest spray were recorded with maximum moisture content (86.49%) while minimum moisture content (77.07%) was observed when flowers were sprayed with distilled water and stored at room temperature.

Flowers sprayed with BA 50 ppm and stored for one day under refrigerated conditions showed maximum moisture content (92.43%) as shown in table 3b. In contrast, minimum moisture content (70.33%) was observed when flowers were sprayed with the distilled water and stored for five days at room temperature.

Table 3a: Effect of pre-harvest spray treatments and storage on moisture content (%) of marigold flowers after storage

Pre-harvest spray Treatments (T)	Storage durations (D)					Mean	Storage conditions(C)	
	1 Day	2 Days	3 days	4 days	5 days		Cold Storage (4 °C)	Room temperature
BA (50 ppm)	91.38	88.50	84.50	81.17	78.50	84.81	86.49	83.13
Jeevamrut	88.83	86.17	83.00	79.00	75.83	82.57	83.87	81.27
Control (distilled water)	86.33	83.17	78.83	76.50	72.17	79.40	81.73	77.07
Mean	88.85	85.94	82.11	78.89	75.50		84.02	80.49
Storage conditions						CD $_{0.05}$ for T: 0.30 D x T: 0.66 D: 0.38 C x D: 0.54 C: 0.24 C X T: 0.42		
Cold Storage (4 °C)	90.26	88.00	84.00	80.67	77.22			
Room temperature	87.44	83.89	80.22	77.11	73.78			

Table 3b: Interaction effect of pre-harvest treatments (T) × Storage condition(C) × Storage duration (D) on moisture content (%) of marigold flowers after storage

Pre-harvest spray Treatments (T)	Storage conditions									
	Cold Storage					Room temperature				
	Storage duration (D)					Storage duration (D)				
	1 day	2 days	3 days	4 days	5 days	1 Day	2 Days	3 days	4 days	5 days
BA50ppm	92.43	90.33	86.33	83.00	80.33	90.33	86.67	82.67	79.33	76.67
Jeevamrut	90.33	87.67	83.67	80.33	77.33	87.33	84.67	82.33	77.67	74.33
Control (distilled water)	88.00	86.00	82.00	78.67	74.00	84.67	80.33	75.67	74.33	70.33
CD$_{0.05}$ for T x C x D: 0.93										

Spoilage (%)

In table 4a, among different pre-harvest sprays, minimum spoilage (11.49%) was observed with BA 50 ppm application; however maximum spoilage (16.32%) was observed in control. These results are in line with Vani and Kumar (2014) [15] who reported that pre-harvest spray of growth regulators reduced the percentage of spoilage over control in baby corn.

Among storage duration, flowers stored for one day were observed with the no spoilage (0.00%) and maximum flower spoilage (28.24%) was observed when the flowers were stored for five days.

In storage conditions, flowers stored under refrigerated conditions showed less spoilage (11.74%) as compared to flowers stored at room temperature (15.98%). Since low temperature slows down microbial activity and respiration rate.

No spoilage was observed in all the three pre harvest spray treatments when stored for one day. On the other hand, maximum spoilage (28.24%) was observed when the flowers were sprayed with the distilled water (control) and stored for five days.

Flowers stored under refrigerated conditions for one and two days and under room temperature for one day showed no spoilage. In contrast, maximum flower spoilage (31.76%) was observed when the flowers were stored for five days under room temperature.

Interaction between pre-harvest treatments and storage conditions shows that minimum flower spoilage (9.83%) was observed when flowers were sprayed with the BA 50 ppm and stored under refrigerated conditions. Maximum flower spoilage (18.98%) was observed when flowers were sprayed with distilled water and stored under room temperature.

Perusal of data presented in table 4b on the interaction effect of storage condition, storage durations and treatments indicates that no spoilage was observed when the flowers were sprayed with all three treatments and stored under refrigerated conditions for first two days while maximum spoilage (37.67%) was observed when flowers sprayed with distilled water and stored for five days under room temperature conditions.

Table 4a: Effect of pre-harvest spray treatments and storage on spoilage (%) of marigold flowers

Pre-harvest spray Treatments (T)	Storage durations (D)					Mean	Storage conditions (C)	
	1 Day	2 Days	3 days	4 days	5 Days		Cold Storage (4 °C)	Room temperature
BA (50 ppm)	0.00 (0.00)	2.80 (6.84)	12.45 (20.64)	18.22 (25.24)	23.97 (29.25)	11.49 (16.39)	9.83 (14.24)	13.14 (18.55)
Jeevamrut	0.00 (0.00)	4.42 (8.64)	14.83 (22.62)	22.07 (27.99)	27.58 (31.63)	13.77 (18.18)	11.73 (15.65)	15.82 (20.70)
Control (distilled water)	0.00 (0.00)	5.20 (9.40)	17.61 (24.79)	25.62 (30.73)	33.17 (35.10)	16.32 (19.93)	13.66 (17.01)	18.98 (22.86)
Mean	0.00 (0.00)	4.14 (8.30)	14.96 (22.68)	21.97 (27.87)	28.24 (31.99)	-	11.74 (15.63)	15.98 (20.70)
Storage conditions						CD $_{0.05}$ T: 0.15 D x T: 0.34 D: 0.20 C x D: 0.28 C: 0.12 C X T: 0.22		
Cold Storage (4 °C)	0.00 (0.00)	0.00 (0.00)	13.88 (21.82)	20.12 (26.59)	24.71 (29.75)			
Room temperature	0.00 (0.00)	8.28 (16.59)	16.05 (23.55)	23.82 (29.14)	31.76 (34.24)			
Figures in parentheses are angular transformed values								

Table 4b: Interaction effect of pre-harvest spray treatment (T) × Storage condition (C) × Storage duration (D) on spoilage (%) of marigold flowers

Pre-harvest spray Treatments (T)	Storage conditions									
	Cold Storage					Room temperature				
	Storage duration (D)					Storage duration (D)				
	1 Day	2 days	3 Days	4 days	5 days	1 day	2 days	3 days	4 Days	5 Days
BA 50 ppm	0.00 (0.00)	0.00 (0.00)	11.63 (19.93)	16.87 (24.24)	20.67 (27.03)	0.00 (0.00)	5.60 (13.68)	13.27 (21.35)	19.57 (26.24)	27.27 (31.46)
Jeevamrut	0.00 (0.00)	0.00 (0.00)	13.77 (21.77)	20.10 (26.63)	24.80 (29.85)	0.00 (0.00)	8.83 (17.28)	15.88 (23.48)	24.03 (29.34)	30.35 (33.42)
Control (distilled water)	0.00 (0.00)	0.00 (0.00)	16.23 (23.75)	23.40 (28.92)	28.67 (32.36)	0.00 (0.00)	10.40 (18.81)	18.99 (25.82)	27.83 (31.83)	37.67 (37.84)
CD$_{0.05}$ T × C × D: 0.48. Figures in parentheses are angular transformed values										

Conclusion

Based on the data interpretation, different preharvest sprays, storage durations and storage conditions significantly affected the quality and post-harvest life of stored flowers. Pre harvest spray of BA 50 ppm along with refrigerated storage for one day, reduced the spoilage percent and enhanced shelf life of marigold with less moisture loss from the flowers, thus flowers can be marketed and used for prolonged period than usual.

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