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ORIGINAL PAPER

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POSTHARVEST IMPACT OF PACKAGING MATERIAL AND STORAGE DURATION ON CUT *Narcissus tazetta*

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ABSTRACT

Narcissus, belonging to Amaryllidaceae family, is one of the emerging cut flower in ornamental industry. Appropriate cut flower packaging for ideal time period provides potential benefit of improving their postharvest quality of flower. Current research was conducted with an objective to find out best suitable packaging materials and optimum storage duration for cut flowers of narcissus. Narcissus postharvest features were analyzed statistically and results showed significant difference among the treatments with respect to packaging material as well as storage duration. In our findings, polyethylene sleeve showed best results in most of postharvest parameters (vase life, total life, dry weight, and change in fresh weight). In our results, 2 hours duration of storage significantly improved the postharvest parameters of cut narcissus. Vase life, fresh and dry weight of flower obtained maximum value in two hours storage duration. It was interesting to note that as storage duration increased, postharvest characters reduced. In conclusion, postharvest quality of cut narcissus can be improved significantly by using suitable packaging material and optimizing storage duration.

Key words: vase life, storage, packaging material, cut flower

INTRODUCTION

In horticultural sector, cut flowers are novel products. Value of such crops depends upon longevity of postharvest life [Bayat and Aminifard 2017]. Managing the shelf life is primary component in floral industry. In marketing perspective, maintaining and enhancing the spike quality and vase life is important [Varu and Barad 2008]. Cut flowers packaging is a mandatory step for managing cut flower features durin postharvest management process because this will indicate absolute value of the product at final location. By controlling or preventing the mechanical injury, it functions as a barrier between inside and outside environment and keeps protection the flowers from stressful environmental condition by forming a micro suitable climate within the packaging [van der Sman et al. 1996].

Packaging of cut flowers, with suitable material for appropriate time, provides the possible benefit of increasing vase life and sustaining quality. There is a prior benefit to wrap cut flowers in bunch form,

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within a proper packaging material and after that, place bunches in fiberboard boxes for shielding them from water loss, physical damage and environmental stress. Response of cut flower in different storage conditions depends upon growing types, species and postharvest management [Dastagiri et al. 2017].

Cut flowers are highly perishable and complex part of plant which required appropriate storage protocol and management to keep their freshness and quality [Reid 2002]. Hence, appropriate storage of cut flowers always a main processing step that confirms preservation of desired actual flower color, turgidity in stem and growth stage. With the intention of delay senescence and to improve cut flower storage quality and methods accompanied by storage services should available before flower production to reserve flower quality during transport and management. [Macnish et al. 2009]. Postharvest management of cut flower specialty crops has revealed that cold storage is an imperative aspect in handling quality of cut flower [Lewis and Borst 1993]. An appropriate cold storage treatment facilitates in floral products transportation from the tropical (production) areas to temperate (market) areas [Hansen and Hara 1994]. Two types of cooling storage methods i.e. dry and wet method are used. Cut stems are placed in their basal position with any preservative solution in cooling wet storage while cut stems are rapidly managed and placed in boxes in dry cool storage [Nowak and Rudnicki 1990].

Usually, for long duration, stems should be placed in dry storage condition, while for small duration (1–4 weeks), storage in floral preservatives is ideal [Sacalis 1993]. Low temperature storage also aids in continuous supply to market. Though, together long and short term storage create injury to flower quality and vase life reduction [Serrano et al. 1992]. Cut flowers after harvesting are frequently stored in dry cool conditions at first and during shipping, rehydrated once before placing to market. Dry storage causes dehydration of cut stems and within xylem air emboli is developed [Harbinson et al. 2005].

Narcissus, belonging to Amaryllidaceae family, is a genus of spring-blooming, hardy and ornamental geophyte plant. This genus comprised of about 26 wild species. Narcissus is one of the emerging cut flower in ornamental industry [Sardoei et al. 2013, Asif 2016].

Various cut stems reacted differently on the basis of storage durations and packaging types. Appropriate packaging material utilization for ideal durations provides potential benefit of improving their postharvest life and keeps quality of cut flower. It is greatly vital to determine the ideal duration for cut stems storage that keeps the vigor and quality of flower. Current research was performed to determine and optimize the best appropriate packaging materials and storage duration for cut stems of narcissus flower.

MATERIALS AND METHODS

This experiment was conducted in Postharvest and Floriculture Lab, Institute of Horticultural Sciences, University of Agriculture, Faisalabad. Cut flowers were bought from commercial grower in Islamabad, Pakistan. Cut flowers were harvested at open bud stage early in the morning, and transported to Faisalabad via air conditioned vehicle. On arrival, stems were rehydrated for 2 h at room temperature and trimmed to 16 cm length, followed by tagging and packing according to the treatments. There were three different packaging materials viz newspaper, kraft paper, polyethylene sheet, flower box with and without flower box for first experiment and three different storage durations, viz 2, 4 and 6 days at 4 ±2°C for second experiment. Each treatment had 15 stems. The stems were stored in postharvest cold storage room, after specified durations the stems were taken out from cold storage room and recut to 14 cm length and placed in postharvest floriculture laboratory at 20 ±2°C in glass jars containing 300 mL of distilled water having 3 stems in each jar to evaluate their vase life.

Data collection and statistical analysis. Each experiment was laid out in Complete Randomized Design (CRD) with factorial arrangement having three replications. In first factor, different packaging materials were used i.e. P_0 = No packaging, P1 = Kraft paper, P_2 = Polyethylene sheet, P_3 = Newspaper, P_4 = Flower box, P_5 = Kraft paper + Flower box, P_6 = Polyethylene sheet + Flower box, P_7 = Newspaper + Flower box while in second factor four treatments i.e. T_0 = 0 days, T_1 = 2 days at 4 ±2°C, T_2 = 4 days at 4 ±2°C, T_3 = 6 days at 4 ±2°C.

Data were recorded for various postharvest parameters such as: vase life (days), change in stem weight during vase life (g), change in stem weight during storage (g), water uptake (mL) per stem, ion leakage (%), dry weight of a flower stem (g), total life (days), change in flower opening (count), petal necrosis (%), change in pH and change in EC (dS m^{-1}). Data collected were analyzed statistically using Fisher' analysis of variance (ANOVA) techniques [Steel et al. 1997]. The means values were compared with least significance difference (LSD) test.

RESULTS

Effect of packaging material

Postharvest characteristics of narcissus cut stems were analyzed statistically and showed significant difference among the treatments with respect to packaging material. Cut narcissus obtained vase life after packing in polyethylene sleeve treatment i.e. 7.6 days and polyethylene + floral box treatment i.e. 7.3 days which was more than remaining packaging treatment (Tab. 1). Instead, minimum vase life of narcissus was found in flower box packaging (5.89 days). Similar results were obtained in longest total life parameter and after that, polyethylene + floral box packaging showed higher value (11.2 d). Shortest total life i.e. 9.9 days of narcissus was found in floral box packing treatment. Highest value of dry weight was shown by packed in polythene treatment i.e. 0.67 g, after that flower packed by Kraft paper treatment and newspaper treatment i.e. 0.62 g and 0.56 g showed significant values. In contrast, the mean Table 1. showed noticeably that control treatment i.e. without any packaging material has reasonably highest value of water uptake (mL) than packaging treatments.

Lowest effect in fresh weight change during storage was noted when flowers were polyethylene packing along with floral box treatment (0.28 g). In addition, after that polyethylene sleeve treatment showed minimum change in fresh weight i.e. 0.32 g. Lowest change in fresh weight (0.26 g) at the time of vase solution was found when flowers were in polyethylene sleeve treatment. Remarkably, no significant variation were observed in fresh weight change in vase solution with polyethylene sleeve (0.26 g), Kraft paper plus flower box (0.32 g), polyethylene plus flower box (0.38 g), newspaper plus flower box (0.40 g) and newspaper (0.52 g). Instead highest fresh weight change during vase solution was expressed by Kraft paper and flower box treaments i.e. 0.64 g each.

Table 1. Effect of packaging material on vase life, total life, change in fresh weight during storage, change in fresh weight during vase solution, dry weight, change in flower opening and water uptake of narcissus stems. Means separation within columns by Fisher's LSD at P ≤ 0.05

Treatment	Vase life (d)	Total life (d)	CFW Storage (g)	CFW vase solution (g)	Dry weight (g)	Change in flower opening	Water uptake (mL)
No packaging	6.73 ±0.12 cd	6.58 ± 0.04 f	–0.947 ±0.08 d	0.46 ±0.09 b	0.49 ±0.01 b	0.98 ±0.05b	24.71 ±1.18a
Newspaper (NP)	6.29 ±0.33 d	11.1 ±0.13 b	–0.947 ±0.08 d	0.52 ±0.09 ab	0.56 ±0.02 b	0.57 ±0.10d	19.67 ±1.58b
Polythene (P)	7.60 ±0.11 a	11.6 ±0.10 a	–0.320 ±0.07 ab	0.26 ±0.03 c	0.67 ±0.03 a	0.97 ±0.19b	17.00 ±1.18d
Kraft paper (KP)	7.16 ±0.25 b	10.2 ±0.16 d	–0.613 ±0.08 bc	0.64 ±0.09 a	0.62 ±0.02 b	1.02 ±0.14b	22.33 ±1.68ab
Floral box (FB)	5.89 ±0.28 e	9.9 ±0.17 e	–1.027 ±0.13 d	0.64 ±0.53 a	0.41 ±0.37 c	0.84 ±0.16c	16.67 ±1.05d
FB + NP	6.49 ±0.21 cd	10.3 ±0.16 d	–0.787 ±0.07 cd	0.40 ±0.17 bc	0.45 ±0.19 c	1.02 ±0.18b	18.00 ±1.53c
FB + P	7.31 ±0.21 ab	11.2 ±0.14 b	–0.287 ±0.04 a	0.38 ±0.14 bc	0.53 ±0.17 b	0.77 ±0.16c	18.67 ±1.58c
FB + KP	6.73 ±0.20 c	10.7 ±0.13 c	–0.800 ±0.06 cd	0.32 ±0.09 c	0.52 ±0.16 b	1.28 ±0.15a	20.67 ±2.00b
Probability	0.0000	<0.0001	0.0000	0.0000	<0.0001	0.0640 NS	0.0802 NS

CFW – change in fresh weight
Means which are having same alphabets in a column are statistically no significant while the means which are having different alphabets are statistically significant

Table 1 clearly depicted that kraft paper packing along with floral box has reasonably more change in flower opening than control and other packaging treatments.

Lowest ion leakage (102%), was found when polyethylene + floral box treatment was used for flower packing subsequently polyethylene sleeve treatment obtained lowest value i.e. 105%. Instead, highest ion leakage (120%) was detected in flower box treatment as shown in Figure 1. Highest value of change in pH was found when flowers were packed in kraft paper alongwith flower box (0.64). Treatments kraft paper in flower box, polyethylene sleeve in flower box, newspaper in flower box, kraft paper and polyethylene sleeve did not show any significant difference statistically (Fig. 1).

It is clear from the Figure 1 that control (No Packaging) has comparatively more change in EC than all packaging material. Similar results were obtained for petal necrosis. Minimum petal necrosis of cut narcissus was observed when cut stems were packed in polyethylene sleeve (35%), followed by polyethylene + floral box (44%).

In Table 3, results showed that strongest correlation (r = 0.858) was observed between change in flower opening and change in EC while highest value of negative correlation (r = –0.729) was observed between dry weight of flower and Ion leakage. Negative correlation between vase life and Ion leakage (r = –0.710) depicted that with the decrease of ion leakage, vase life increased.

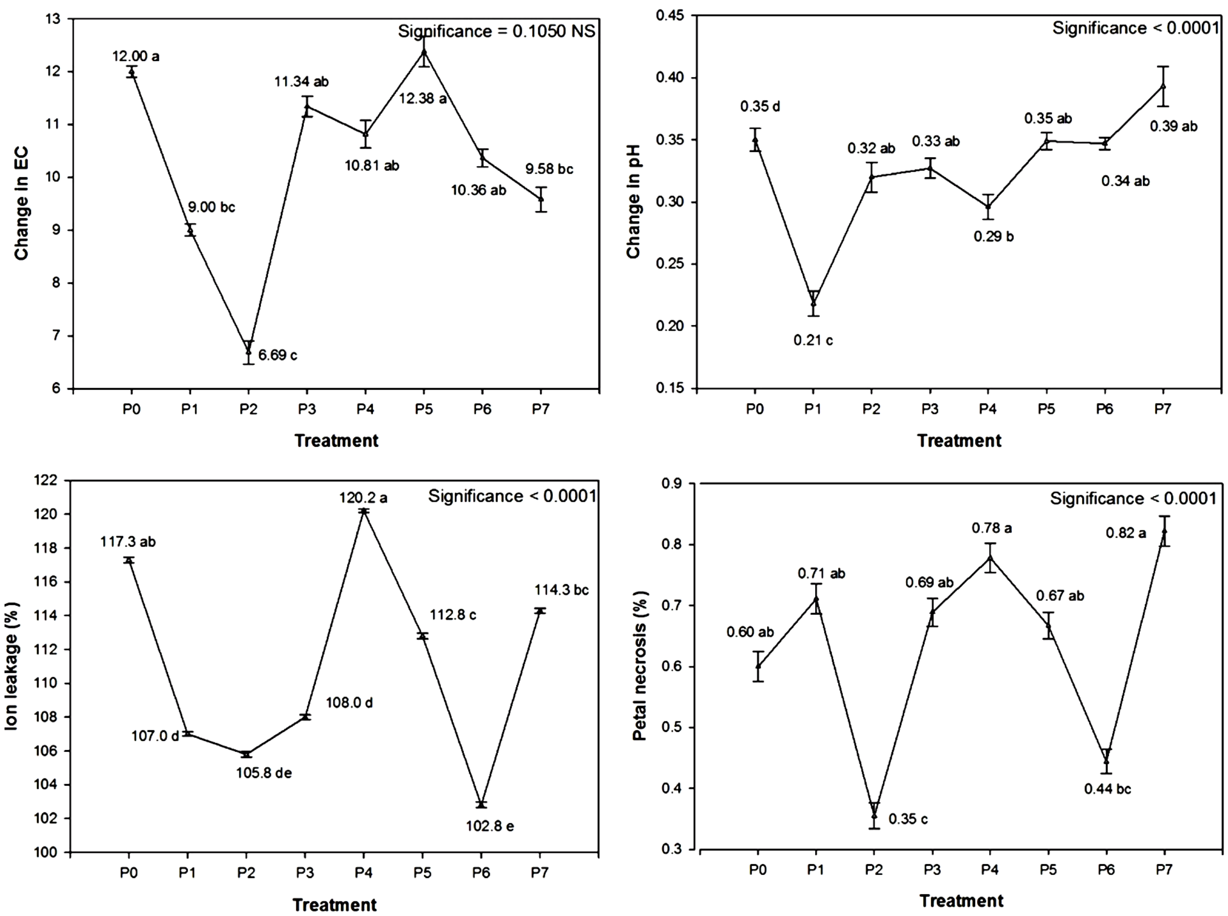

Fig. 1. Effect of packaging material on Change in EC, Cahge in pH, Ion leakage and Petal necrosis of narcissus stems. Means separation in graph is by Fisher's LSD at $P \leq 0.05$

Effect of storage duration

Regarding storage duration of cut narcissus, longest vase life was observed when stored for 2 days (7.76 d) while shortest vase life was observed when stored for 6 days (5.88 d). There is a clear trend that with the increase in storage duration, vase life of cut narcissus declined. In case of total life parameter, maximum value was observed when stored for 6 days i.e.11.76 d while minimum value was observed when stored for 2 days (9.7 d). There is a clear trend with the increased in storage duration, total life of cut narcissus increase as shown in Table 2. In case of water uptake character, results showed that with the increase of storage duration, water uptake for cut narcissus decline. Highest water uptake of cut narcissus was observed when stored for 2 days (23.1 mL) while lowest water uptake was observed when stored for 6 days (15.57 mL).

Regarding storage duration minimum change in fresh weight during storage of cut narcissus was observed when stored for 2 days (0.60) while maximum change in fresh weight during storage was observed when stored for 6 days (0.81). Similar as above parameter, with the increase in storage duration, change in fresh weight also increases as shown in Table 2. Maximum fresh weight during vase solution of cut narcissus was observed when stored for 2 days (0.59) while minimum change in fresh weight during vase solution was observed when stored for 4 days (0.30). There was a clear trend that with the increased in storage duration, change in fresh weight during vase solution of cut narcissus declined as shown in Table 2. In contrast, storage duration had non-significant effect on dry weight for cut narcissus flower.

In ion leakage results (Fig. 2), minimum ion leakage of cut narcissus was observed when stored for 2 days (120%) while maximum ion leakage was observed when stored for 6 days (139%). Contrastingly, maximum change in pH of cut narcissus was observed when stored for 2 days (0.34) while minimum change in pH was observed when stored for 6 days (0.29). In our results, for change in flower and EC parameters, control (no packaging) has comparatively maximum values than storage durations. With respect to storage duration, no statistical difference was found for petal necrosis characteristic.

In Table 4, strongest correlation (r = 0.956) was observed between dry weight of flower and change in flower weight during storage while highest value of negative correlation (r = –0.967) was observed between dry weight of flower and change in EC. Negative correlation between vase life and Ion leakage (r = –0.710) depicted that with the decrease of ion leakage, vase life increased. Furthermore, total life, ion leakage, change in flower opening, change in EC and petal necrosis have negative impact with respect to vase life.

DISCUSSION

There is a need to transport the flowers to elongated distances in striking condition which involves

Table 2. Effect of storage duration on vase life, total life, change in fresh weight during storage, change in fresh weight during vase solution, dry weight, change in flower opening and water uptake of narcissus stems. Means separation within columns by Fisher's LSD at P ≤ 0.05

Storage	Vase life (d)	Total life (d)	CFW storage (g)	CFW vase solution (g)	Dry weight (g)	Change in flower opening	Water uptake (mL)
0 days	6.73 ±0.12 b	6.58 ± 0.04 d	–0.947 ±0.08 c	0.46 ±0.09 ab	0.49 ±0.01 c	0.98 ±0.05 a	24.71 ±1.18 a
2 days	7.76 ±0.08 a	9.7 ±0.139 c	–0.609 ±0.066 a	0.59 ±0.362 a	0.557 ±0.240 a	0.87 ±0.09 a	23.00 ±1.14 a
4 days	6.70 ±0.14 b	10.6 ±0.158 b	–0.629 ±0.064 a	0.30 ±0.324 c	0.533 ±0.250 ab	0.87 ±0.11 a	18.43 ±0.89 b
6 days	5.88 ±0.14 c	11.8 ±0.146 a	–0.811 ±0.075 b	0.40 ±0.334 b	0.512 ±0.257 b	1.06 ±0.11 a	15.57 ±0.57 b
Probability	0.0000	<0.0001	0.0070	0.0000	0.091 NS	0.3170 NS	<0.041

CFW – change in fresh weight
Means which are having same alphabets in a column are statistically no significant while the means which are having different alphabets are statistically significant

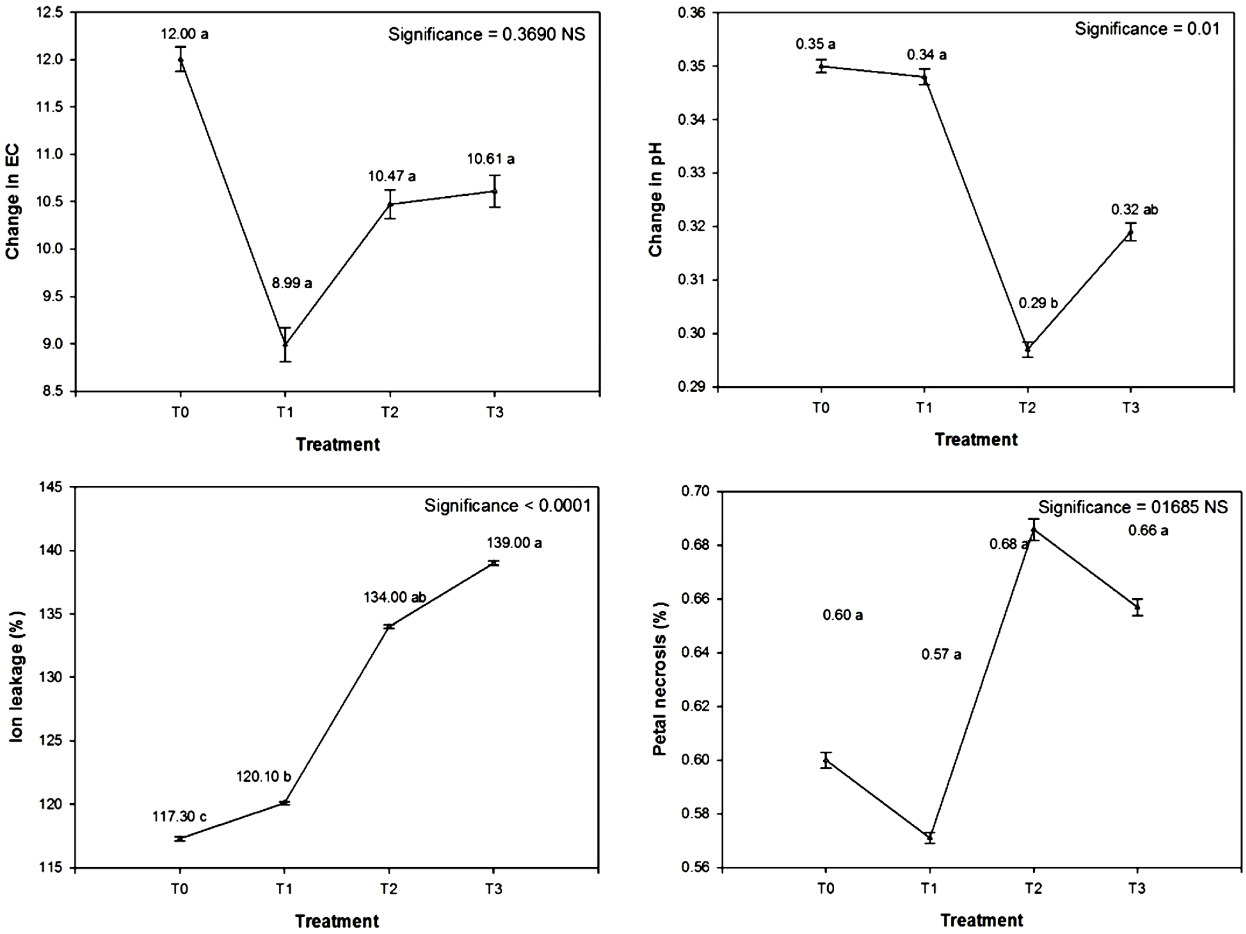

Fig. 2. Effect of storage duration on change in EC, change in pH, ion leakage and petal necrosis of narcissus stems. Means separation in graph is by Fisher's LSD at P ≤ 0.05

good transportation amenities and the use of suitable packaging materials and preservative chemicals. This is necessary to regulate the sustained supply of flowers [Farooq et al. 2004]. In our findings, polyethylene sleeve showed best results in most of postharvest parameters (vase life, total life, dry weight, and change in fresh weight). Chakrabarty et al. [2012] also found that polyethylene packaging performed the best compare to other packaging materials which could enhance vase life, facilitating maximum flowers to be opened at a time with minimum weight loss throughout the vase life in tuberose cut spikes. Vase life and storage of cut rose flowers may be improved by packaging in aluminum lamination foil. However, such packaging materials should be used which are easily available, firm, cheap, and non-moisture absorbent. Varu and Barad [2008] conceded out experiment to calculate the role of packing methods on vase life of tuberose. The spikes wrapped in 200 gauge polyethylene sheet (P2) in which the packing methods were found for elongated vase life of spike, lowest loss uptake ratio extreme uptake of water, better freshness as well as lowest wilting of highest percentage of opened florets and florets. Thomas et al. [2013] conducted research to compare the postharvest cut roses life (*Rosa hybrids* L.) when packed in newspaper, polyethylene, brown paper, butter paper and without any packing material. Three days after packing, extreme wilting was observed in unpacked flowers following by flowers packing in brown paper, newspaper and butter pa-

Table 3. Correlation between various characteristics of narcissus stems under different packaging materials

	VL	TL	DW	WU	CFWS	CFWV	IL	CFO	pH change	EC change
TL	0.264									
DW	0.785	0.435								
WU	0.105	–0.717	0.072							
CFWS	0.907	0.530	0.649	–0.256						
CFW	–0.534	–0.277	–0.285	0.190	–0.520					
IL	–0.710	–0.643	–0.729	0.158	–0.801	0.327				
CFO	0.238	–0.161	0.015	0.243	0.056	–0.352	0.339			
pH change	0.369	–0.224	–0.130	0.238	0.275	–0.455	0.194	0.858		
EC change	–0.414	–0.624	–0.686	0.427	–0.446	0.484	0.475	0.128	0.284	
PN	–0.544	0.076	–0.351	–0.376	–0.503	–0.287	0.526	0.150	–0.081	–0.313

Table 4. Correlation between various characteristics of narcissus stems under different storage durations

	VL	TL	DW	WU	CFWS	CFWV	IL	CFO	pH change	EC change
TL	–0.351									
DW	0.665	0.463								
WU	0.707	–0.905	–0.057							
CFWS	0.522	0.555	0.956	–0.212						
CFWV	0.690	–0.336	0.334	0.621	0.047					
IL	–0.723	0.876	0.026	–0.994	0.207	–0.700				
CFO	–0.805	0.089	–0.728	–0.376	–0.764	–0.136	0.341			
pH change	0.497	–0.680	–0.118	0.790	–0.387	0.884	–0.846	0.088		
EC change	–0.581	–0.543	–0.967	0.134	–0.877	–0.439	–0.079	0.539	0.029	
PN	–0.704	0.571	–0.167	–0.795	0.108	–0.965	0.856	0.150	–0.958	0.235

per whereas smallest wilting was appearing in flowers packed in polyethylene. Cut gerbera flowers pulsing with the sucrose 5% + $AgNO_3$ 20 ppm + RT + 24 h and packed with the plastic sleeves with the different aerations for whole flower scape and flower head only in the corrugated fibre board boxes (CFB) with tissue papers (TP) and newspapers (NP) as bedding materials, showing significant results relating to postharvest quality [Prashanth and Chandrasekar 2010].

Cut flowers stand extremely complex and perishable plant body part that want to be suitably stored and handled to reserve their quality and value [Reid 2002]. Therefore, suitable storing of cut flowers remains a dynamic treatment stage that certifies preservation of wanted original flower color, turgor and development period. In order to slow down senescence and to improve cut flower keeping quality, storage methods should be well planned along with storage facilities must be available before produce to reserve produce quality throughout transit, handling and to decrease transport cost [Macnish et al. 2009]. In our results, 2 hours duration of storage significantly improved the postharvest parameters of cut narcissus. Vase life, fresh and dry weight of flower obtained maximum value in two hours storage duration. In Saffron (*Crocus sativus* L.) flowers were harvested at semi-bloom form stage, and placed in plastic baskets, in two different thickness accumulations (10 and 15 cm). The flowers were stored at 0, 4, 8 and 21°C for after 2, 4, 7, 14 and 21 days. During storage period, weight loss percentage was calculated. In addition, the stigmas were separated from the styles and dried in an oven at 60°C. Bioactive compounds such as crocin, picrocrocin and safranal, and coliform enumeration were evaluated. The result indicated that weight loss percentage increased with increasing storage thickness, temperature and storage duration; however bioactive compounds reduced [Azarpaahooh and Sharayei 2015].

As storage duration increased, postharvest characters reduced. Water stress, imbalance of hormone, nutrient depletion and variation in environmental factors (relative humidity, temperature) can accelerate the flower senescence [Teixeira da Silva 2003]. Furthermore, correlation between different characteristics in storage and packaging material effect depicted the negative correlation of most of postharvest parameters with respect to vase life character. These findings are in conformity with the results of Asif [2016] reported that the total life, dry weight, of cut tuberose improved by packaging material and storage duration. Maximum total life of cut tuberose was recorded by polyethylene sleeve and stored for 6 days (11.6 d). Similarly, it is stated that, long term storage reduced vase life of bird of paradise flowers, with small reduction in flowers pulsed with sucrose immediately after cold storage. Maximum storage longevity of birds of paradise resulted when flower storage was at 10°C for 14 days [Finger et al. 2002]. Similar to our findings, Tshwenyane [2014] reported that increased in storage duration there is decline in fresh weight of chrysanthemums cut flower for a longer period. Cold storage delays flower development and provides a longer vase life [Redman et al. 2002]. This change in membrane properties results increased cell membrane permeability which enhances electrolyte leakage from chill injured cells and tissues [Kim et al. 2002].

Dastagiri et al. [2017] found that cut stems of chincherinchee storing for 3 days showed best performance with respect to freshness and color during postharvest life. With the increased of storage duration, flower quality reduced. Similar findings were observed in tuberose by Waithaka et al. [2001] and in lily by Sharma et al. [2008]. There were no significant difference in case of termination symptoms i.e. petal wilt and leaf necrosis etc. in case of storage duration treatments. With the increase of storage of duration causes carbohydrates reduction in stems. In addition, carbohydrates stored in leaves are translocated to florets or opening flowers. This may results in leaf chlorosis and necrosis [Jowkar 2006, Gul and Tahir 2013]. In contrast, results indicated that ion leakage and change in EC were increased with the increase of storage duration. These findings are in conformity with the results of Saleem [2013] who reported that the ion leakage of cut gladiolus improved by storage duration increment.

CONCLUSION

Postharvest quality of cut narcissus can be improved significantly by using packaging material and optimizing storage duration. Best packaging material is polyethene for longer period storage than other packaging material in our findings. Furthermore, long term storage duration i.e. more than 2 days affects the quality parameters of cut narcissus.

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