Journal of Horticultural Science & Ornamental Plants 4 (1): 75-83, 2012
ISSN 2079-2158

Effect of Dry and Wet Storage at Cool Temperatures on Postharvest Performance of *Narcissus tazetta* cv. Kashmir Local Flowers

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Abstract: An experiment was conducted to determine the optimal harvest maturity stage for short term cool dry or wet storage in *Narcissus tazetta* cv. Kashmir Local. The scapes were harvested at 0800 h when the scapes were at tight bud stage. The harvested scapes were cut to a uniform size of 20 cm and processed for dry and wet storage at 5 and 10°C. A separate set of scapes each for dry and wet storage was kept at room temperature (15 ±2°C). After 72 h of storage the scapes were kept at room temperature in test solutions viz. distilled water, Sucrose (0.15M) and Sucrose (0.15M) + 8-HQS (50 mg L^{-1}). The average vase life of scapes was assessed to be terminated when 50% open flowers senesced, which was characterized by loss of turgor followed by wilting of tepals. The scapes dry or wet stored at 5 and 10°C for 72 h had maintained their premature status, whereas flowers on most of the scapes had generally bloomed during storage at room temperature. The results of our experiments showed that the scapes previously wet stored in distilled water for 72 h at 5°C before transfer to Sucrose (0.15M) + 8-HQS (50 mg L^{-1}) exhibited marked improvement in blooming, solution uptake, maintenance of membrane integrity, fresh or dry mass of flowers, sugar fractions and soluble proteins with a corresponding decrease in α- amino acids. The present results suggest that cool wet storage of premature scapes of *Narcissus tazetta* for 72 h at 5°C in distilled water improved subsequent postharvest performance in the holding solution (Sucrose +8- HQS) and can be used as an effective postharvest strategy for this beautiful cut flower.

Key words: *Narcissus tazetta* · Dry and wet storage · Cut flower · Postharvest performance

INTRODUCTION

Floriculture is an emerging and fast expanding globalised market as a result studies on postharvest handling of cut flowers occupy a pivotal position. The term postharvest is applicable for processes happening to flowers after detachment from mother plant [1]. Postharvest may include physical (temperature, humidity), chemical (vase solutions, floral preservatives) or biological (optimal harvest) factors capable of delay in senescence. Temperature and optimal harvest maturity stage are important factors for control of quality loses in cut flowers [2-8]. Immature scapes may not open fully, besides the petals of flowers harvested at fully open stage are prone to damage and increased packaging costs. Modes of proper storage besides temperature requirements need to be identified at variety levels within a species [9-12]. Vase solutions containing preservatives, carbohydrates, biocides, plant growth regulators, ethylene antagonist are effective in preventing many disorders apart from providing nutrients necessary for flower opening, sustaining normal development and preventing bacterial growth within the vase [5, 6, 13-17].

Narcissus tazetta (Amaryllidaceae) commonly called as Narcissus blooms from February to March in Kashmir. The plant possesses glorious cluster of fragrant white flowers [2-7] borne on hollow scape which can attain a height of about 35 cm. Only little information is available on the improvement of *Narcissus tazetta* as a cut flower [9, 18]. The present study was undertaken to determine optimal harvest maturity stage, proper mode of storage and postharvest performance in distilled water (DW), Sucrose (SUC) and 8-Hydroxyquinoline Sulphate(8-HQS).

MATERIALS AND METHODS

Plant Material: Scapes of *N. tazetta* cv. Kashmir Local growing in the University Botanic Garden were used for the study. The scapes were harvested at 0800 h when they were at tight bud stage (Fig. 1). The stage was

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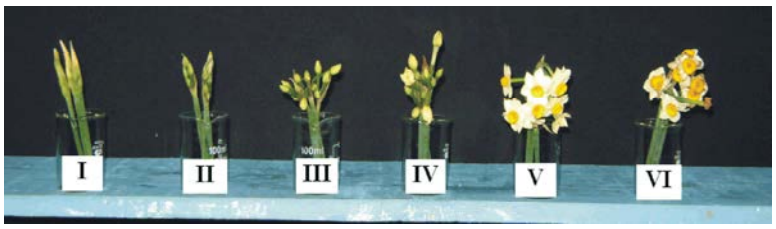

Fig. 1: Different stages of scape development in *Narcissus tazetta*. Stages III was selected for present experimental studies was designated as tight bud stage when the spathe had broken and buds were just countable

carefully selected after preliminary trials on less mature and more mature developmental stages. The harvested scapes were brought to the laboratory, cut to a uniform size of 20 cm and processed for dry and wet storage. For dry storage the scapes were wrapped in moistened filter papers, packed in perforated cardboard boxes and kept in cooling incubators in dark at 5 and 10°C for 72 h. For wet storage, the scapes were held for 72 h in 1000 ml glass beakers containing distilled water, kept in cooling incubators in dark at 5 and 10°C. A separate set of scapes each for dry and wet storage was kept at room temperature (15 ± 2°C). After 72 h of dry and wet storage the scapes kept at room temperature were transferred into 250 ml conical flasks containing 200 ml of holding solutions viz. distilled water (DW), Sucrose (SUC 0.15M) or Sucrose and 8-Hydroxyquinoline sulphate (SUC 0.15M + 8-HQS 50 mg L^{-1}). The samples were kept under cool white fluorescent light with a mix of diffused natural light (10 Wm^{-2}) 12 h a day and RH of 60±10%. The day of transfer of scapes to the holding solution was designated as day zero.

Assessment of Vase Life, Blooming and Solution Uptake: The average vase life of the scapes was counted from the day of transfer of scapes to the holding solution and was assessed to be terminated when 50 % flowers had senesced, which was characterized by loss of turgor followed by tepal wilting. The experiment was maintained till the vase life in the last set of scapes was regarded to be terminated. Number of blooms per scape was recorded on alternate days up to day 4 of the transfer. Volume of holding solutions absorbed per scape was recorded on day 2, 4 and 6 after the transfer. The volume of holding solution absorbed by the scapes was calculated by measuring the volume of vase solutions on a particular day and subtracting it from the initial quantity of the vase solution kept in the flasks taking into account the volume of the solution evaporated by using blank flasks (containing vase solution) without scapes.

Conductivity of Leachates, Fresh and Dry Mass of Flowers: Conductivity of leachates from tepal discs, besides fresh and dry mass of flowers was recorded on day 4 of transfer of scapes to holding solutions. The changes in membrane permeability were estimated as the conductivity of leachates (µS) of tepal discs (5 mm in diameter) incubated in dark in 15 ml glass distilled water for 15 h at 20°C. Dry mass was determined by drying the material in an oven for 48 h at 70°C.

Estimation of Tissue Constituents: Changes in tissue constituents including sugar fractions, soluble proteins, α-amino acids and phenolics were estimated on day 4 after transfer. For estimating tissue constituents (sugars, α-amino acids and phenols) 0.5 g chopped material of perianth tissue was fixed in triplicate in hot 80 % ethanol. The material was macerated and centrifuged three times. The supernatants were pooled and used for the estimation of sugars, free amino acids and total phenols. Reducing sugars were estimated by the method of Nelson [19] using glucose as the standard. Total sugars were estimated after enzymatic conversion of non-reducing sugars into reducing sugars with invertase. Non-reducing sugars were calculated as the difference between total and reducing sugars. α-amino acids were estimated by the method of Rosen [20] using glycine as standard. Total phenols were estimated by the method of Swain and Hillis [21] using gallic acid as standard. Proteins were extracted from 0.5 g perianth tissue drawn separately from different flowers. The tissue was homogenized in 5 ml of 5 % sodium sulphite (w/v) adding 0.1 g of polyvinylpyrrolidone and centrifuged. Proteins were precipitated from a suitable volume of cleared supernatant with equal volume of 20 % trichloroacetic acid, centrifuged at 1000 × g for 15 minutes and the pellet redissolved in 0.1 N NaOH. Proteins were estimated from a suitable aliquot by the method of Lowry *et al.* [22] using BSA as the standard. Each treatment was represented by five replicates (flasks) and each flask contained two scapes.

Statistical Analysis: Data was analyzed statistically and LSD computed at $P_{0.05}$ using MINTAB (version 11).

RESULTS

The average life of an individual flower on the scape after it had opened fully was about 5 days. Flower senescence was assessed when 50 % of flowers had lost their display value which was characterized by loss of turgor followed by wilting of tepals. The vase life of scapes wet stored for 72 h was higher than dry stored scapes. The average vase life of scapes dry stored at room temperature was 2 days in DW, 3 days in SUC and 4 days in SUC +8-HQS, whereas the average vase life of scapes wet stored at room temperature was 3 days in DW, 5 days in SUC and 6 days in SUC + 8-HQS (Table 1). The scapes dry stored at 10 and 5°C showed an increment of 2 or 3 days in DW, 3 days each in SUC and 1 or 4 days

Table 1: Effect of dry and wet storage at different temperature regimes on vase life and blooming of *Narcissus tazetta* scapes (dry or wet stored for 72 h) before transfer to distilled water, Sucrose (0.15M) or SUC (0.15M) + 8-HQS (50mgL^{-1})

			No. of blooms per scape					
	Vase life (days)		Dry storage			Wet storage		
Temperature Treatment (72 h)	Dry storage	Wet Storage	Days after treatment					
			0	2	4	0	2	4
RT→DW	2	3	4.75 (95)	4.75 (95)	-	4.50 (90)		
10°C→DW	4	7	3.51 (70)	3.51 (70)	-	3.11 (62)	4.90 (98)	
5°C→DW	5	10	0.26 (5)	0.26 (5)	5.00 (100)	0.11 (2.50)	3.09 (62)	5.00 (100)
RT→SUC (0.15M)	3	5	4.73 (95)	4.73 (95)	-	4.65 (90)	5.00 (100)	-
10°C→SUC (0.15M)	5	8	3.52 (70)	3.52 (70)	-	2.90 (62)	4.92 (99)	-
5°C→SUC (0.15M)	6	11	0.25 (5.0)	0.25 (5.0)	5.00 (100)	0.10 (2.51)	4.02 (80)	5.00 (100)
RT→SUC (0.15M) +8-HQS (50 mg L^{-1})	4	6	4.76 (95)	4.76 (95)	-	4.80 (90)	5.00 (100)	-
10°C→SUC (0.15M) +8-HQS (50 mg L^{-1})	5	9	3.53 (70)	3.53 (70)	-	2.91 (62)	4.90 (97)	-
5°C→SUC (0.15M) +8-HQS (50 mg L^{-1})	8	12	0.25 (5.0)	0.25 (5.0)	5.00 (100)	0.10 (2.50)	4.10 (82)	5.00 (100)
LSD at $P_{=0.05}$	0.30	0.70	0.02	0.02	-	0.05	0.03	

Each value is a mean of 5 independent replicates
Room temperature (RT) = (15±2°C)
Figures in parentheses represent percent blooms

Fig. 2: Scapes of *Narcissus tazetta* after 72 h dry storage (A) and after 72h wet storage (B). Form left to right are arranged scapes kept at room temperature (RT, 15± 2°C), 10°C and 5°C respectively. Note that the scapes kept at RT under dry or wet storage had already bloomed during storage

Fig. 3: Effect of postharvest dry storage for 72 h at room temperature (RT), 10° and 5°C before transfer to DW, SUC (0.15M) and SUC (0.15M)+ 8-HQS (50 mg L^{-1}) on day 8 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local. From left to right are arranged flasks containing scapes stored at RT (15 ± 2°C), 10° and 5°C. Sub Figs. A to C represent scapes dry stored at RT, 10 and 5°C and held in DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) respectively

SUC + 8-HQS, respectively. The average vase life of scapes wet stored at 10 and 5°C was enhanced by days 4 to 6 days in DW, 3 to 6 days both in SUC and SUC + 8-HQS. The scapes stored under dry or wet conditions for 72 h at room temperature had bloomed during storage, whereas the scapes kept at 5 and 10°C maintained their premature status (Fig. 2, A-B). The scapes held at 10 and 5°C (dry or wet) maintained a sustained rate of blooming in holding solutions which could perhaps enhance their longevity and completed 100% blooming by day 4 of transfer to various holding solutions (Fig. 3 A-C). Sustained rate of blooming at 5 and 10°C after storage could be due to reduced metabolic processes (Fig. 4 A-C).

The volume of holding solution absorbed was slightly higher in scapes wet stored for 72 h particularly at 5°C as compared to dry stored scapes. Preferential uptake of SUC +8-HQS followed by SUC was observed suggesting a possible decrease in xylem blockade due to reduced microbial growth on addition of biocide (Table 2). The ion leakage of tepal discs showed considerable decrease in samples from wet stored scapes as compared to the corresponding dry stored scapes. A significant decrease in membrane leakage was noticed in samples form scapes wet or dry stored at 5°C and held in 8-HQS+SUC. The flowers of scapes wet stores at 10 or 5°C showed a significant increase in fresh and dry mass as compared to flowers from corresponding dry stored scapes (Table 3). A highly significant increase was recorded in the content of carbohydrate content (reducing sugars, non-reducing sugars and total sugars) of samples form wet stored scapes as compared to dry stored scapes. The content of sugars was higher in samples from scapes stored (dry or wet) at 10 or 5°C and held in SUC+8-HQS as compared to samples form scapes held at room temperature (Table 4). A significant increase in the content of soluble proteins, phenols and a decrease in α-amino acids were recorded in the samples from wet stored scapes as compared to the corresponding dry stored scapes. The increase in the protein content was higher in samples from scapes stored (dry or wet) at 10 or

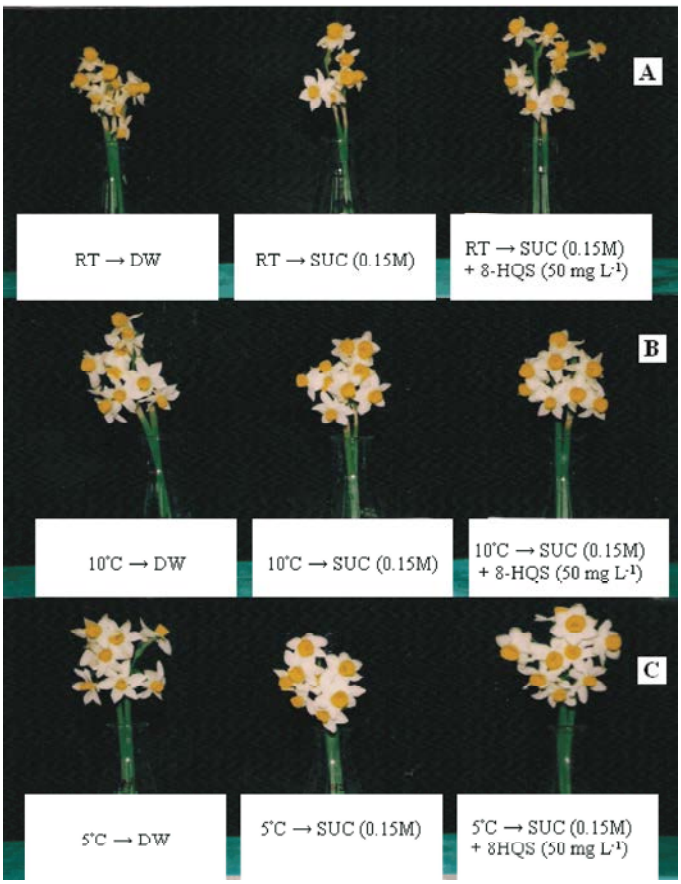

Fig. 4: Effect of postharvest wet storage for 72 h at room temperature (RT), 10° and 5°C, before transfer to DW, SUC (0.15M) and SUC(0.15M)+ 8-HQS (50 mg L^{-1}) on day 8 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local. From left to right are arranged flasks containing scapes stored at RT (15± 2°C), 10° and 5°C. Sub Figs. A to C represent scapes wet stored at RT, 10 and 5°C held in DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) respectively

Table 2: Effect of dry and wet storage at different temperature regimes on solution uptake in cut scapes of *Narcissus tazetta* (dry or wet stored for 72 h) before transfer to distilled water, Sucrose (0.15M) or SUC (0.15M) + 8-HQS (50mgL^{-1})

	Volume of holding solution absorbed per scape (ml) Days after treatment					
	Dry Storage			Wet storage		
Temperature Treatment (72 h)	2	4	6	2	4	6
RT→DW	1.41	2.08	3.08	0.52	1.29	3.34
10°C→DW	1.54	2.45	3.56	1.26	3.06	4.23
5°C→DW	1.87	3.00	4.20	1.56	3.30	4.48
RT→SUC (0.15M)	1.35	2.33	3.28	1.72	1.78	3.53
10°C→SUC (0.15M)	1.62	2.79	4.00	1.76	3.54	4.78
5°C→SUC (0.15M)	1.95	3.79	4.65	2.30	4.03	4.93
RT→SUC (0.15M) +8-HQS (50 mg L^{-1})	1.80	2.70	3.49	2.01	3.97	5.25
10°C→SUC (0.15M) +8-HQS (50 mg L^{-1})	1.87	3.00	4.20	2.12	4.26	5.68
5°C→SUC (0.15M) +8-HQS (50 mg L^{-1})	2.83	4.66	5.41	2.50	4.58	6.19
LSD at $P_{=0.05}$	0.12	0.12	0.18	0.06	0.04	0.02

Each value is a mean of 5 independent replicates

Room temperature (RT) = (15±2°C)

Table 3: Effect of dry and wet storage at different temperature regimes on conductivity of leachates, fresh mass and dry mass of flowers in scapes of *Narcissus tazetta* (dry or wet stored for 72 h) on day 4 before transfer to distilled water, Sucrose (0.15M) or SUC (0.15M) + 8-HQS (50 mg L^{-1})

	Conductivity of leachates (µS)		Fresh mass (g $flower^{-1}$)		Dry mass (g $flower^{-1}$)	
Temperature treatment (72h)	Dry storage	Wet storage	Dry storage	Wet storage	Dry storage	Wet storage
RT→DW	30.66	21.00	0.247	0.445	0.038	0.044
10 °C→DW	13.00	14.66	0.418	0.489	0.041	0.055
5 °C →DW	9.66	8.33	0.470	0.559	0.047	0.057
RT→SUC (0.15M)	22.33	19.33	0.283	0.509	0.043	0.053
10°C→SUC (0.15M)	11.33	13.33	0.442	0.519	0.050	0.064
5°C→SUC (0.15M)	8.33	6.66	0.500	0.589	0.057	0.073
RT→SUC (0.15M) +8-HQS (50 mg L^{-1})	13.66	16.33	0.326	0.522	0.049	0.063
10°C→SUC (0.15M) +8-HQS (50 mg L^{-1})	10.33	10.66	0.465	0.542	0.056	0.068
5°C→SUC (0.15M +8-HQS (50 mg L^{-1})	7.33	4.66	0.605	0.647	0.068	0.077
LSD at $P_{=0.05}$	0.66	0.80	0.040	0.020	0.006	0.004

Each value is a mean of 5 independent replicates

Room temperature (RT) = (15±2°C)

Table 4: Effect of dry and wet storage at different temperature regimes on sugar fractions from tepal tissue in cut scapes *Narcissus tazetta* (dry or wet stored for 72 h) on day 4 before transfer to distilled water, Sucrose (0.15M) or SUC (0.15M) + 8-HQS (50 mg L^{-1})

	Reducing sugars		Non-reducing Sugars		Total sugars	
Temperature treatment (72h)	Dry storage	Wet storage	Dry storage	Wet storage	Dry storage	Wet storage
RT→DW	1.86	2.66	0.80	0.79	2.66	3.46
10°C→DW	3.46	7.46	1.16	0.86	4.63	8.32
5°C→DW	5.33	6.93	0.70	2.40	6.13	9.33
RT→SUC (0.15M)	3.73	6.13	0.53	0.81	4.26	6.93
10°C→SUC (0.15M)	5.06	10.66	2.50	2.93	7.56	13.60
5°C→SUC (0.15M)	6.66	8.05	3.46	9.33	10.13	17.86
RT→SUC (0.15M) +8-HQS (50 mg L^{-1})	5.86	8.50	1.04	4.00	6.93	12.53
10°C→SUC (0.15M) +8-HQS (50 mg L^{-1})	8.26	13.33	1.00	2.13	9.33	15.46
5°C→SUC (0.15M +8-HQS (50 mg L^{-1})	9.86	14.93	2.65	4.80	12.53	19.73
LSD at $P_{=0.05}$	0.40	0.44	0.18	0.18	0.72	0.62

Each value is a mean of 5 independent replicates

Room temperature (RT) = (15±2°C)

Table 5: Effect of dry and wet storage at different temperature regimes on soluble proteins, amino acids and total phenols from tepal tissue in cut scapes of *Narcissus tazetta* (dry or wet stored for 72 h) on day 4 before transfer to distilled water, Sucrose (0.15M) or SUC (0.15M) + 8-HQS (50 mg L^{-1})

	Soluble proteins		α-amino acids		Total phenols	
Temperature treatment (72h)	Dry storage	Wet storage	Dry storage	Wet storage	Dry storage	Wet storage
RT→DW	2.16	5.58	0.74	0.66	5.46	8.33
10°C→DW	3.16	6.16	0.46	0.68	3.06	6.06
5°C→DW	4.58	6.58	0.42	0.59	1.80	5.00
RT→SUC (0.15M)	2.83	6.08	0.67	0.62	6.86	9.06
10°C→SUC (0.15M)	4.66	7.08	0.41	0.61	3.53	6.93
5°C→SUC (0.15M)	5.91	7.83	0.37	0.50	2.73	6.26
RT→SUC (0.15M) +8-HQS (50 mg L^{-1})	4.16	7.33	0.55	0.59	8.26	9.93
10°C→SUC (0.15M) +8-HQS (50 mg L^{-1})	5.41	7.91	0.34	0.55	4.20	7.73
5°C→SUC (0.15M +8-HQS (50 mg L^{-1})	7.25	9.58	0.32	0.44	3.40	7.33
LSD at $P_{=0.05}$	0.50	0.24	0.016	0.01	0.18	0.52

Each value is a mean of 5 independent replicates

Room temperature (RT) = (15±2°C)

5°C and held in SUC+8-HQS as compared to samples form scapes held at room temperature in SUC or DW (Table 5). In the present study, pertaining to the effect of dry or wet storage, at different temperatures regimes on the cut flower performance of *Narcissus tazetta*, both dry and wet handling were found to improve the postharvest performance without any deleterious effects during or after storage. Wet handling was more effective than dry in enhancing the vase life.SUC+8-HQS was found to be more suitable vase solution as compared to SUC or DW.

DISCUSSION

Postharvest studies on ornamentals occupy a pivotal role in the emerging floricultural business all over the world. Postharvest physiology spans over the time period from harvest or removal of plant from its normal growing environment to the time of utilization. The present results suggest absence of deleterious effects of storage (dry or wet) at cool temperatures (chilling injury, spike or scape bending, bud abortion, petal curling, color change) as reported earlier in plants such as *Curcuma alismatifolia*, *Amaryllis belladonna* were not observed in the present investigation [5, 23]. Thermal or chemical regulation of senescence in enhancing vase life and improving postharvest performance have assumed considerable significance in ornamental horticulture [24- 26]. Vase life of *N. tazetta* scapes stored at 5°C considerably increased as compared to the controls. Low temperature is recognized as the most important factor for the successful storage of cut flowers by reducing both plant metabolic processes and microbial growth rate; besides delaying the symptoms of senescence through regulation at biochemical level [13, 28]. Chemical regulation by 8-HQS has been found to improve the vase life and water uptake of many cut flowers such as *Tuberose, Phalaenopsis, Leptospermum scoparium, Amaryllis belladonna, Nerine sarniensis* [5-6, 29-30]. Tight bud stage is a potential stage for effective storage of *N.tazetta* scapes in both dry or wet handlings. Appropriate stage of harvest has been found to influence the appearance, longevity and vase life of several cut flowers [5-8, 16, 31-33]. Scapes of *N. tazetta* stored at low temperature maintained higher fresh and dry mass of flowers. Low temperatures have been reported to enhance the maximum fresh mass achieved in cut rose flowers; besides a higher storage temperature has been shown to decrease the initial increment in fresh mass of *Grevillea* 'Sylvia' inflorescences [14, 34]. Storage at low temperature (5°C) in both dry and wet handlings maintained a higher sugar content. The concentration of various carbohydrate fractions such as glucose, fructose and sucrose has been shown to increase at low temperature regimes in cut roses [14]. The effect of low temperature can be attributed to the increase in carbohydrate content in tepals, thus enhancing the influx of water and osmolyte into tepal cells. Higher protein content was observed in tepal tisssues of *N. tazetta* scapes stored at 5°C particularly in wet storage concomitantly a lower amino acid content was observed in tepal tissues of scapes stored at room temperature. Low temperature maintained a high protein content in the perianth tissue probably by inhibiting specific proteases responsible for protein degradation. These results corroborate with the observations on *Nerine sarniensis* (Amaryllidaceae) by Gul and Tahir [6]. Higher phenol content was observed in wet stored scapes; a high content of total phenols has been associated with longer vase life in cut rose petals Mwangi *et al*. [35]. The present results suggested that the scapes of *N. tazetta* cv. Kashmir Local harvested at the right stage (tight bud satge) can provide a good model for market flexibility as an export cut flower crop. The scapes may be cool stored at 5°C for 72 before transferring them into vase solutions without affecting their subsequent vase life.

ACKNOWLEDGEMENTS

The authors thank HOD department of Botany, Prof. Zafar A Reshi, for providing the facilities, Prof. A.Q. Jhon, for the cultivar identification. Fahima Gul thanks the Kashmir University authorities for providing the university scholarship.

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