

Effect of Different Storage Treatments on Physiology and Postharvest Performance in Cut Scapes of Three *Iris* Species

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ABSTRACT

The effect of different storage temperatures on senescence and postharvest performance in cut scapes of three *Iris* species (*Iris germanica*, *Iris reticulata* and *Iris kashmiriana*) was studied with the aim to develop a cost-effective storage protocol so as to bring out the transportation of these cut flowers. The scapes were subjected to two different storage treatments-dry storage and wet storage. For dry storage, the scapes were wrapped in moistened filter papers and kept at different storage temperatures [RT (20±2°C), 10 and 5°C] for 72 hours. For wet storage, the scapes were kept in buckets containing distilled water (DW) and kept at different storage temperatures [RT (20±2°C), 10°C and 5°C] for 72 hours. After 72 hours storage, the scapes were transferred to flasks containing either DW or sucrose 0.15 M (SUC). Storage of buds for 72 hours at 5°C, followed by transfer to DW and SUC improved longevity in all the three species. Cold storage treatment before transfer to holding solutions improved floral diameter, membrane integrity and maintained higher fresh and dry mass of flowers, sugar content, and soluble proteins. In all the three species studied, enhanced vase life was found associated with the decrease in the total phenolic content of the perianth tissue. In conclusion, our results suggest that wet and dry storage of premature scapes of Irises for 72 hours at 5°C, and placing them in sucrose improves the cut flower performance and can be used as effective postharvest storage treatments for these beautiful cut flowers.

Keywords: Cold storage, Phenols, Postharvest, Senescence, Sugars, Vase life.

INTRODUCTION

Irises are wonderful garden plants. *Iris* is a genus of 260 species of flowering plants with showy flowers. It takes its name from the Greek word for a rainbow, referring to the wide variety of flower colors found among the many species. These ornamental plants have high commercial value as cut flowers; however, their short flower life limits the length of storage and vase life. Several biotic and abiotic stresses can affect flower longevity, including exhaustion of carbohydrate supply, sensitivity to ethylene, xylem obstruction and infection by microorganisms (Finger and Barbosa, 2006). Rapid cooling and proper temperature are

key requirements for maintaining the vitality of cut flowers. Refrigerated storages provide growers with the capability of extending the useful life of cut flowers and, therefore, widening the market window for the product. Temperature is considered the most important factor affecting the quality and longevity of cut flowers (Cevallos and Reid, 2001; Leonard *et al.*, 2001; Gul *et al.*, 2009; Shahri *et al.*, 2009; Shahri and Tahir, 2011). At lower temperatures, flowers have a lower respiration rate and consume their stored energy much slower. Under physiological temperatures, a negative correlation has been observed between the increase in temperature and reduction of flower longevity (Cevallos and Reid, 2001). Cold

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storage facilitates preservation of commodities and aims at maintenance of the harvested cut flowers in 'fresh' condition, markedly affecting the consumer acceptability, thus, rendering storage as an important procedure in supply and demand regulation. The dry or wet storage method is a widely used method; however, the effect of storage type is variable and dependent on temperature ((Rudnicki *et al.*, 1991). In this context, the present work was conducted to investigate the influence of temperature and wet versus dry storage on senescence and postharvest longevity of three *Iris* species.

MATERIALS AND METHODS

Plant Material

Uniform and healthy scapes of three *Iris* spp. (*Iris germanica*, *Iris reticulata* and *Iris kashmiriana*) growing in the Kashmir University Botanic Garden (KUBG) were used for the study. The scapes were harvested at 12:00 hour with their oldest bud at '1 day before anthesis' stage. The harvested scapes were immediately brought to the laboratory, cut to a uniform length of 35 cm in *Iris germanica* and 40 cm in *Iris reticulata* and *Iris kashmiriana*, and processed for dry and wet storage. For dry storage, the scapes were wrapped in moistened filter papers, packed in perforated polyethylene flower sleeves (40 cm long and 15 cm wide top) and kept in cooling incubators under dark conditions at 5 and 10°C. For wet storage, the scapes were held in buckets containing distilled water kept in cooling incubators under dark conditions at 5 and 10°C. A separate set of scapes each for dry and wet storage was kept at room temperature (20±2°C) under simulated conditions (RH-60±10%). After 72 hours dry or wet storage, the scapes were kept at room temperature and transferred to 250 ml Erlenmeyer flasks containing 200 ml of holding solutions: distilled water (DW) or 0.15M sucrose (SUC). The flasks were kept under cool white fluorescent light with a mix

of diffused natural light (10 W m⁻²) 12 hours a day and RH of 60±10%. The day of transfer of scapes to (DW) or (SUC) was designated as day zero. The experiments were repeated thrice.

Assessment of Vase Life and Solution Uptake

The average vase life of the scapes was counted from the day of transfer of scapes to the holding solutions and was assessed to be terminated when flowers lost their ornamental/display value (wilted and lost turgidity). The volume of holding solution absorbed by the scapes was calculated by measuring the volume of solution 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 particular solution evaporated by using blank flasks in triplicate (containing particular vase solution without scapes) alongside the flasks with scapes.

Blooming, Fresh and Dry Mass

Number of blooms per scape as well as fresh and dry mass of the flowers was determined at periodic intervals. Dry mass was determined by drying the material in an oven for 48 hours at 70°C.

Tissue Constituents

One gram 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 and total phenols. Reducing sugars were estimated by the method of Nelson (1944) using glucose as the standard. Total soluble sugars were estimated after enzymatic conversion of non reducing sugars into reducing sugars with invertase (BDH). Total phenols were estimated by the

method of Swain and Hills (1959) using gallic acid as the standard. Soluble proteins were extracted from 1 g petal tissue drawn separately from five 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 0.1N NaOH. Proteins were estimated from a suitable aliquot by the method of Lowry *et al.* (1951) using BSA as the standard.

Statistical Analysis

Each treatment was represented by five replicates (flasks) and each flask contained two scapes. Each value represents the mean of five replicates. The data has been analyzed statistically and LSD computed at $P_{0.05}$ using MINITAB (v 15. 1.2-EQUINOX_Softddl.net) software.

RESULTS

Vase Life and Solution Uptake

The average life of individual scapes (harvested and placed immediately in holding solutions) of *Iris germanica* and *Iris reticulata* was about 3 days in DW and 4 days in sucrose and for *Iris kashmiriana*, it was 2 days in DW and 3 days in sucrose. All the three species exhibited similar pattern of flower senescence involving initial wilting and loss of turgor in tepals, followed by the appearance of translucent water-soaked areas on petal margins and finally inrolling of perianth lobes. The scapes stored under dry conditions for 72 hours maintained their premature status irrespective of storage temperature. However, the buds stored under wet conditions for 72 hours at 10°C and room temperature (RT) had bloomed during storage as compared to the corresponding

buds stored at 5°C (Figure 1 (A-F)). Vase life of scapes registered a general increase with the decrease in storage temperature both under dry and wet storage. In *Iris germanica*, the average vase life of scapes stored under dry conditions at 5°C was about 8 and 10 days in DW and SUC, respectively, whereas the wet stored scapes at 5°C exhibited a vase life of about 10 and 11 days, respectively. In *Iris kashmiriana*, the average vase life of scapes stored under dry conditions at 5°C was about 7 and 10 days in DW and SUC, respectively, whereas the wet stored scapes at 5°C exhibited a vase life of about 8 and 11 days, respectively. In *Iris reticulata*, the average vase life of scapes stored under dry or wet conditions at 5°C was about 6 and 7 days in DW and SUC, respectively (Figures 2 (A-B) and Figure 3-a).

In all the three *Iris* species that were kept under different storage conditions (dry and wet), the volume of the holding solution absorbed per scape increased with the progression in time. The volume of holding solution absorbed was higher in scapes previously stored under dry or wet conditions at 5°C as compared to the corresponding scapes stored at 10°C and RT. In *Iris germanica*, the scapes previously wet stored at 5°C before transfer to holding solutions showed increased solution uptake as compared to the corresponding scapes stored under dry conditions, while as in *Iris reticulata* and *Iris kashmiriana*, increased solution uptake was registered by scapes previously stored under dry conditions (Figure 3-b).

Blooming, Fresh and Dry Mass

The dry and wet storage of scapes at cool temperature (5°C) resulted in higher and sustained rate of blooming as compared to the corresponding scapes stored at higher temperature (10°C and RT). In *Iris germanica*, maximum blooming was achieved in scapes previously wet stored at 5°C before transfer to SUC. Storage of

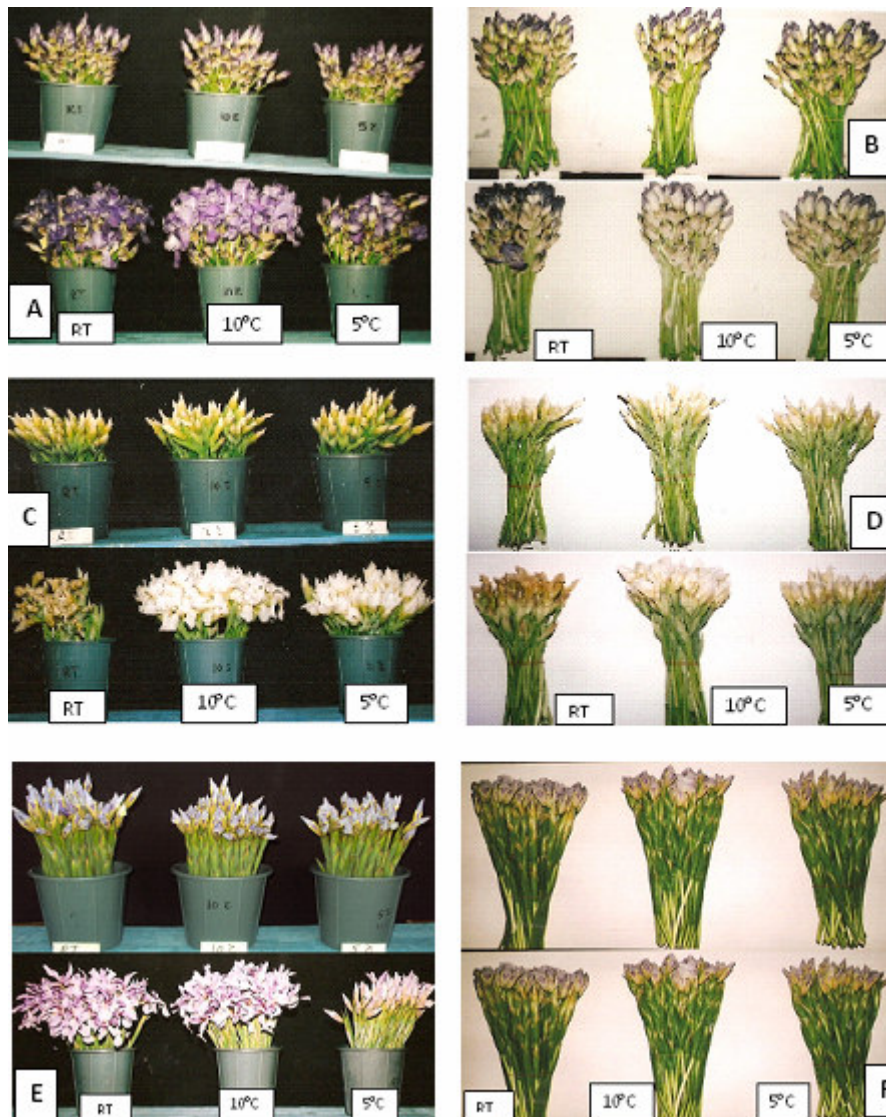


Figure 1. (A) Scapes of *Iris germanica* before and after 72 hours wet storage; (B) Scapes of *Iris germanica* before and after 72 hours dry storage; (C) Scapes of *Iris kashmiriana* before and after 72 hours wet storage; (D) Scapes of *Iris Kashmiriana* before and after 72 hours dry storage; (E) Scapes of *Iris reticulata* before and after 72 hours wet storage, and (F) Scapes of *Iris reticulata* before and after 72 hours dry storage.

scapes at 5°C under dry or wet storage resulted in an increased fresh and dry mass of flowers as compared to that of the corresponding scapes stored at 10°C and RT. A higher fresh and dry mass was maintained in samples from scapes transferred to SUC as compared to that of corresponding scapes transferred to DW (Figure 3 c-d and e).

Tissue Constituents

The tissue content of soluble proteins in samples from scapes of *Iris germanica*, stored under dry conditions, registered an initial decrease with the decrease in storage temperature at day 1 of transfer to DW or

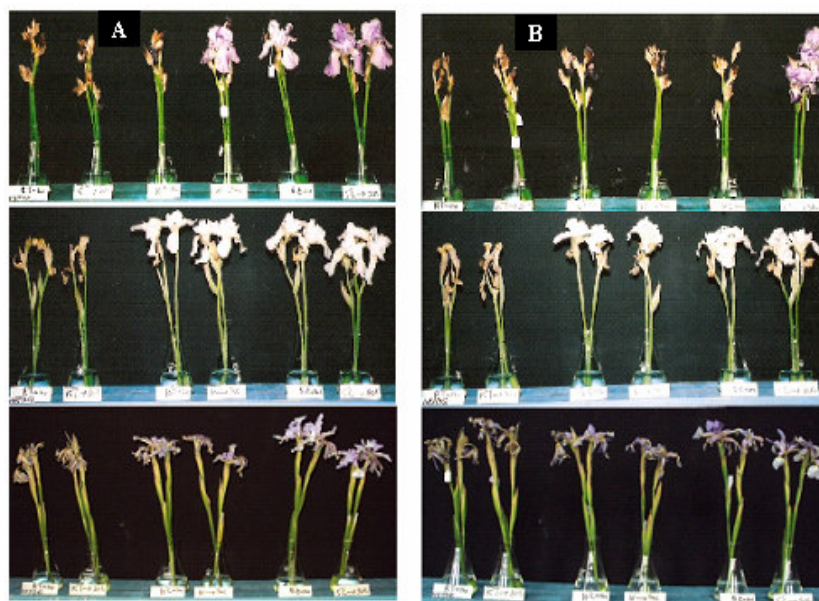


Figure 2. (A) Scapes of *Iris germanica*, *Iris kashmiriana* and *Iris reticulata* in various holding solutions after 72 hours wet storage at day 8, 6 and 6 of transfer, respectively. (B) Scapes of *Iris germanica*, *Iris kashmiriana* and *Iris reticulata* in various holding solutions after 72 hours dry storage at day 8, 8, and 4 of transfer, respectively. From left to right, flasks are arranged containing scapes as RT-DW, RT-SUC, 10°C-DW, 10°C-SUC, 5°C-DW and 5°C-SUC.

SUC. As the time progressed from day 1 to day 4 of transfer, a higher soluble protein content was maintained in samples from scapes dry stored at 5°C as compared to that of the corresponding scapes stored at 10°C and RT. However, in *Iris reticulata* and *Iris kashmiriana*, dry or wet storage of scapes at 5°C resulted in the maintenance of higher content of soluble proteins in the perianth tissue as compared to that of the corresponding scapes stored at 10°C and RT. In all the three *Iris* species, a higher content of soluble proteins was maintained in samples from scapes previously dry or wet stored before transfer to sucrose (Figure 3-f). The tissue content of total as well as reducing sugars in samples from *Iris germanica* and *Iris kashmiriana* registered a general decrease with the progression in time, irrespective of the storage conditions. However, in *Iris reticulata*, the samples from scapes stored under dry or wet conditions before transfer to sucrose registered an increase in the tissue content of sugars as compared to that of the samples from the corresponding scapes transferred to

DW (Figure 3 g and h). In all the three species, storage of scapes under dry or wet conditions at 5°C resulted in a decreased content of the total phenols in perianth tissue as compared to that of the corresponding scapes stored at 10°C and RT (Figure 3-i).

DISCUSSION

The deleterious effects of dry storage at cool temperatures including chilling injury, scape bending, bud abortion or petal curling, as reported earlier in plants such as *Curcuma alismatifolia* and *Amaryllis belladonna*, were not observed in the present investigation (Bunya-Atichart *et al.*, 2004; Gul *et al.*, 2007). In *Iris reticulata* and *Iris kashmiriana*, in all the three species, the enhanced vase life was recorded in scapes kept at 5°C under dry or wet storage transferred to either DW or SUC as compared to the corresponding scapes kept at higher temperatures (10°C and room temperature). Storage of scapes at cool temperatures did not increase the longevity

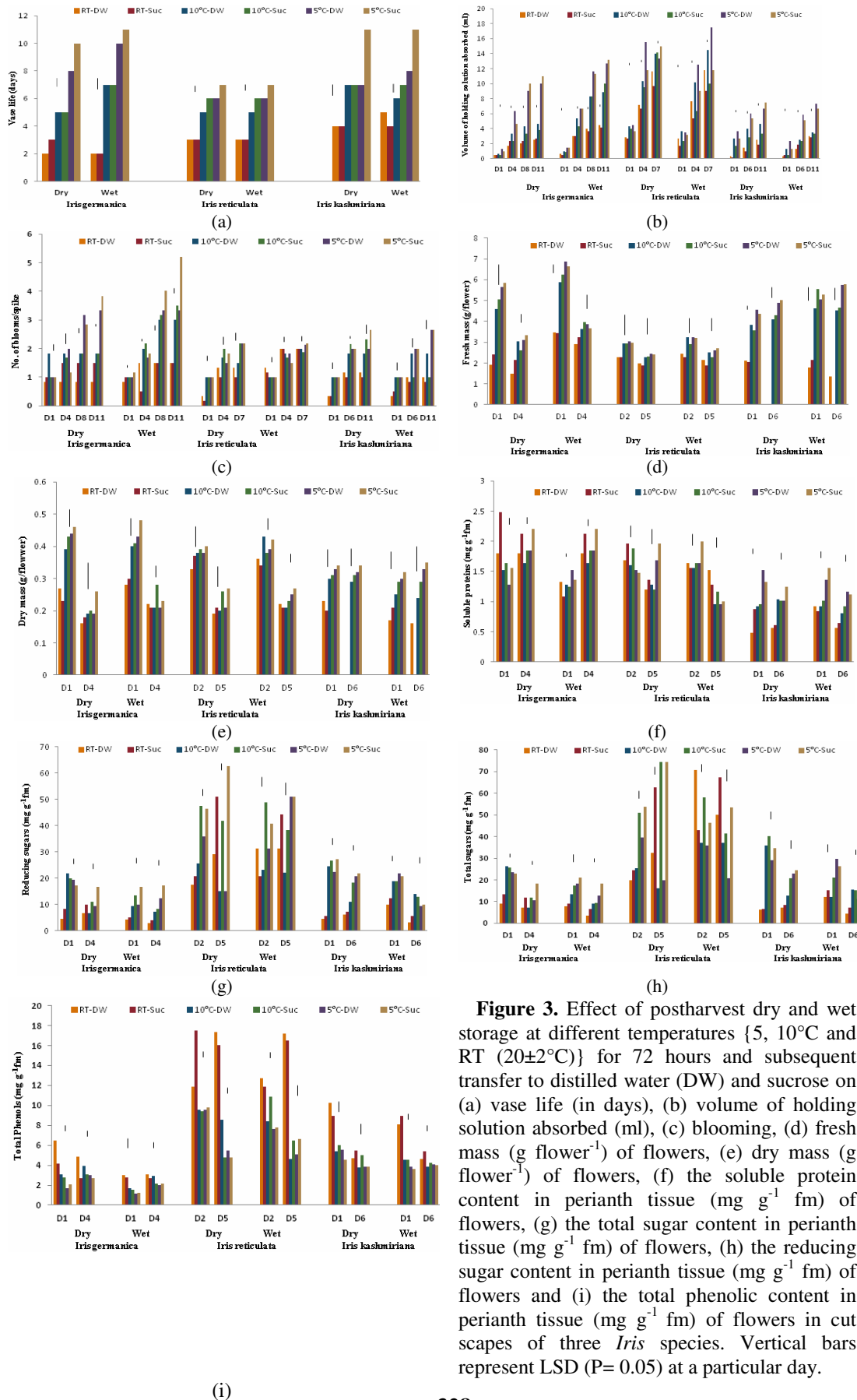


Figure 3. Effect of postharvest dry and wet storage at different temperatures {5, 10°C and RT (20±2°C)} for 72 hours and subsequent transfer to distilled water (DW) and sucrose on (a) vase life (in days), (b) volume of holding solution absorbed (ml), (c) blooming, (d) fresh mass (g flower⁻¹) of flowers, (e) dry mass (g flower⁻¹) of flowers, (f) the soluble protein content in perianth tissue (mg g⁻¹ fm) of flowers, (g) the total sugar content in perianth tissue (mg g⁻¹ fm) of flowers, (h) the reducing sugar content in perianth tissue (mg g⁻¹ fm) of flowers and (i) the total phenolic content in perianth tissue (mg g⁻¹ fm) of flowers in cut scapes of three *Iris* species. Vertical bars represent LSD (P= 0.05) at a particular day.

of individual flowers, instead, the increase in vase life was due to the profusion and continuity with which buds bloom into flowers. Reduced metabolic processes at low temperatures have been suggested to sustain the rate of blooming in flowers such as *Amaryllis*, *Consolida* and *Nerine* (Gul *et al.*, 2007; Gul and Tahir, 2009; Shahri *et al.*, 2009). Low temperature, recognized as the most important factor in the successful storage of cut flowers, has been found to reduce both plant metabolic processes and microbial growth rate (van Doorn and de Witte, 1991; Shahri *et al.*, 2009). The postharvest performance of scapes was found to be better in scapes transferred to SUC as compared to the corresponding scapes transferred to DW. Sucrose has been found to improve the postharvest performance of many cut flowers (Ichimura *et al.*, 2000; Gul *et al.*, 2007; Shahri *et al.*, 2010). Sugars, besides supplying respiratory substrates, maintain adequate water balance, decrease sensitivity to ethylene, delay the climacteric ethylene biosynthesis, and delay the increase in mRNA abundance of a number of senescence-associated genes (Ichimura *et al.*, 2000; Pun and Ichimura, 2003; Gul *et al.*, 2007; Hoeberichts *et al.*, 2007; Gul and Tahir, 2009).

The volume of holding solution absorbed per scape was significantly higher in scapes previously dry or wet stored at 5 and 10°C before transfer to DW as compared to corresponding scapes stored at RT. The increased water uptake in buds dry or wet stored at 5 and 10°C corroborates with the earlier findings on *Amaryllis belladonna* and *Nerine sarniensis* (Gul *et al.*, 2007; Gul and Tahir, 2009). In *Iris reticulata* and *Iris kashmiriana* solution uptake was comparatively higher in scapes previously dry stored at 5°C as compared to corresponding buds stored under wet conditions. The comparative increased water uptake in spikes stored under dry conditions could be probably due to the water stress during 72 hours storage. Samples from wet stored scapes were found to maintain

higher fresh and dry mass of flowers as compared to that of samples from scapes stored under dry conditions. Low temperature has been reported to enhance the maximum fresh mass achieved in cut rose and *Consolida* flowers: besides a higher storage temperature has been shown to decrease the initial increment in fresh mass of *Grevillia* 'Sylvia' inflorescences (Ichimura *et al.*, 1999; Joyce *et al.*, 2000; Shahri *et al.*, 2010).

A significant increase in the content of soluble proteins was recorded in scapes dry or wet stored at 5°C. The increase was particularly marked in samples from flowers stored under wet conditions. It has been suggested that low temperatures maintain high protein content in tissues by inhibiting specific proteases responsible for protein degradation (Gul and Tahir, 2009; Shahri and Tahir, 2011). A higher content of reducing and total sugars was maintained in samples from scapes previously dry or wet stored at 5°C as compared to corresponding scapes stored at 10°C and RT. In *Iris reticulata* and *Iris kashmiriana*, the sugar content was comparatively higher in samples from scapes previously stored under dry conditions. The concentration of various sugar fractions such as glucose, fructose, and sucrose has been shown to increase at low temperature regimes in cut roses and *Nerine* (Ichimura *et al.*, 1999; Gul and Tahir, 2009). Gul and Tahir (2009) attributed this increase to enhanced influx of water and osmolytes into cells. Storage of scapes at low temperature (5°C) resulted in a decrease in the tissue content of phenols. Increased vase life was found associated with the decrease in the content of total phenols. However, in cut rose petals, the higher content of phenols has been shown to be associated with longer vase life (Mwangi *et al.*, 2003).

In conclusion, the present results suggest that the scapes of three *Iris* species harvested at the right stage (mature bud at one day before anthesis stage) can provide a good model for market flexibility as an export cut flower crop. The scapes may be dry or wet



stored at 5°C for 72 hours before transferring them into vase solutions, without affecting their vase life. This procedure can be used as a cost-effective postharvest storage treatment for these cut flowers.

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تأثیر تیمارهای مختلف انبارداری (نگهداری) روی فیزیولوژی و رفتار پس از برداشت
گلپایه های بریده سه گونه زنبق (سوسن)

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چکیده

در این تحقیق، تأثیر درجه حرارت های مختلف انبارداری (نگهداری) روی پیری و رفتار پس برداشت گلپایه های بریده سه گونه زنبق (سوسن) شامل (*Iris germanica*, *Iris reticulata* and *Iris kashmiriana*) مطالعه شد با این هدف که دستورالعملی اقتصادی برای انبار داری و تعیین روش جابجایی و حمل و نقل این گل‌های بریده تهیه شود. دو تیمار انبار داری خشک و تر بر این گلپایه ها اعمال شد. گلپایه ها در کاغذهای فیلتر مرطوب پیچیده شدند و در درجه حرارت های مختلف شامل (درجه حرارت اتاق ($20 \pm 2^{\circ}\text{C}$) RT و 5°C و 10°C) به مدت ۷۲ ساعت نگهداری شدند. در انبارداری تر، گلپایه ها در سطل هایی حاوی آب مقطر DW در درجه حرارت های مزبور به مدت ۷۲ ساعت نگهداری شدند. پس از این مدت، گلپایه ها به فلاسک هایی حاوی آب مقطر یا سوکروز M₁₅ منتقل شدند. انبارداری غنچه ها برای ۷۲ ساعت در 5°C و به دنبال آن انتقال آنها به سطل های آب مقطر یا سوکروز ماندگاری هر سه گونه را بهبود بخشید. تیمار انبارداری سرد قبل از انتقال به محلول های نگهدارنده باعث افزایش قطر گلها، یکپارچگی ممبران و حفظ جرم تازه و خشک گلها، محتوای قند ها، و پروتئین های محلول شد. در هر سه گونه، افزایش عمر گلجایی (گلدانی) با کاهش محتوای کل فنل در بافت های پوشا همراه بود. دستاورد کلی بر اساس نتایج این تحقیق اینکه، نگهداری تر و خشک گلپایه های زنبق (سوسن) به مدت ۷۲ ساعت در درجه حرارت ۵ سانتی گراد و قراردادن آنها در محلول سوکروز ماندگاری گل های بریده را بهبود بخشیده و می توان این کار را به عنوان روشی موثر برای نگهداری پس از برداشت این گل‌های زیبا قلمداد کرد.