Effect of Dry and Wet Storage at Different Temperatures on the Vase Life of Cut Flowers

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SUMMARY. **After storage at different temperatures for a simulated transportation period, the vase lives at 20 °C (68 °F) of carnations (*Dianthus caryophyllus* 'Imperial White'), daffodils (*Narcissus pseudonarcissus* 'King Alfred'), iris (*Iris hollandica* 'Telstar'), killian daisies (*Chrysanthemum maximum*), paperwhite narcissus (*Narcissus tazetta* 'Paperwhite'), roses (*Rosa* (XtimesX)*hybrida* 'Ambiance'), and tulips (*Tulipa gesneriana*) decreased with increasing storage temperature. There were no significant differences between the vase life of flowers stored dry and flowers stored in water when storage temperatures were from 0 to 10 °C (32 to 50 °F). The vase life after wet storage at temperatures of 12.5 °C (54.5 °F) and greater was significantly higher than vase life after dry storage at those temperatures for all the flowers studied. Iris and carnation flowers survived storage at 15 and 20 °C (59 and 68 °F) only when stored in water.**

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Monitoring of transit temperatures of commercial cut flowers has shown that flowers are often exposed to damaging high temperatures. Maxie et al. (1974) and Thompson and Reid (1994) recorded flower temperatures above 27 °C (81 °F) in commercial flower shipments. Poor temperature management during transport of cut flowers is largely the result of inadequate precooling and transport under nonrefrigerated conditions. Several researchers have shown the negative effects of improper storage temperatures on vase life of a range of cut flowers (Cevallos and Reid, 2001). The poor arrival quality of transported cut flowers has spurred the development of systems like the Procona buckets (Pagter Innovations, Dinteloord, The Netherlands) in which the flowers are transported in water. Industry leaders have claimed a considerable improvement in postharvest quality for flowers transported in this way, and these claims have reduced the industry's emphasis on proper postharvest temperature management. Warm storage temperatures accelerate water loss, so it is possible that wet storage helps by replacing lost water. However, we have shown that reduction of cut flower vase life during storage is highly correlated with respiration at the storage temperature (Cevallos and Reid, 1999). A substantial reduction in the vase life of flowers shipped at warmer temperatures would therefore be expected even if they were shipped in water.

In the study reported here, several cut flower species were used to test the hypothesis that wet storage would have a beneficial effect on vase life only when flowers were held at warmer temperatures.

Materials and methods

PLANT MATERIAL. 'King Alfred' daffodils, killian daisies, paperwhite narcissus, and tulips were obtained from a wholesale florist (Bill Suyeyasu Florist, Fremont, Calif., and transported dry under refrigeration to Davis, Calif. 'Ambiance' roses were air-freighted, dry, directly from a wholesale grower/shipper (Consorcio Quitoflores, Quito, Ecuador). 'Imperial White' carnations and 'Telstar' iris were obtained from Kitayama Nurseries (Watsonville, Calif.) and transported in water to Davis, Calif.

STORAGE EXPERIMENT. On receipt, the

flowers were unpacked, recut under deionized water to a length of 15 cm (6 inches) below the head or lowest bud and placed at storage temperatures ranging from 0 to 20 °C for 6 d. Twelve replicate stems of each type of flower were placed at each temperature. Six of them were wrapped in newspaper and perforated polyethylene and stored dry inside a fiberboard box and the remaining six were stored with their stems in deionized water containing 50 mg·L^{-1} (ppm) sodium hypochlorite (NaOCl).

~~Determination of vase life.~~ After storage, the flowers were recut under water to a stem length of 10 cm (4 inches) and placed in deionized water containing 50 mg·L^{-1} NaOC1 in a controlled-environment vase life evaluation room. The controlled environment was kept at a temperature of 20 °C and a relative humidity of about 60%. Artificial light (15 μmol·m^{-2}·s^{-1} PAR) was provided for 12 h each day by cool-white fluorescent tubes (Sylvania Lighting Co., Danvers, Mass.). The flowers were evaluated three times daily and vase life was recorded as the time taken for loss of aesthetic value.

~~Statistical analysis.~~ The standard error of the mean vase life of the six replicate flowers in each treatment was determined.

Results and discussion

Effect of temperature on vase life

Whether the flowers were stored dry or wet, the vase life at 20 °C of all the flowers declined as the temperature during storage increased (Figs 1, 2, 3). The effect of storage temperature on vase life differed, even in closely related species, with daffodils showing a more rapid drop than paperwhites (Fig. 1). Iris flowers were most affected by the storage temperature (Fig. 3), and killian daisies (Fig. 2) were the least affected.

Effect of dry and wet storage

~~Rose 'Ambiance'~~ Vase life (determined as days to petal desiccation, wrinkling and loss of turgidity) was slightly but significantly higher after wet storage than after dry storage at storage temperatures above 5 °C (41 °F) (Fig. 1).

~~Daffodil 'King Alfred'~~ There were no significant differences in the vase life (determined as days to wilting of the perianth) after storage of daffodils dry or wet except for those stored at 12.5 °C, the highest temperature tested (Fig. 1). Vase life after wet storage at 12.5 °C was more than double that after dry storage at that temperature.

~~Narcissus 'Paperwhite'~~ There were no significant differences in the vase life (days to senescence of 50% of the flowers on the scape) after dry or wet storage of narcissus except for a slightly longer vase life for those stored wet at 12.5 °C, the highest temperature tested (Fig. 1).

~~Killian Daisy~~ Vase life (determined by petal browning and loss of turgidity) was not significantly different after wet storage than after dry storage at 0 °C but was slightly better for wet-stored flowers after storage at 12.5 °C (Fig. 2).

~~Tulip~~ Vase life (days to petal desiccation and abscission) was not significantly different after wet storage than after dry storage at 0 °C. The vase life of tulips stored wet at 12.5 °C was half that of flowers stored (wet or dry) at 0 °C, but was more than twice that of flowers stored dry at 12.5 °C (Fig. 2).

~~Iris 'Telstar'~~ There were no significant differences in vase life (determined by in-rolling of the banners followed by discoloration of the tepals) after wet or dry storage of iris at 0, 5, and 10 °C (Fig. 3). Wet storage allowed iris to be stored at 15 and 20 °C, but was ac-

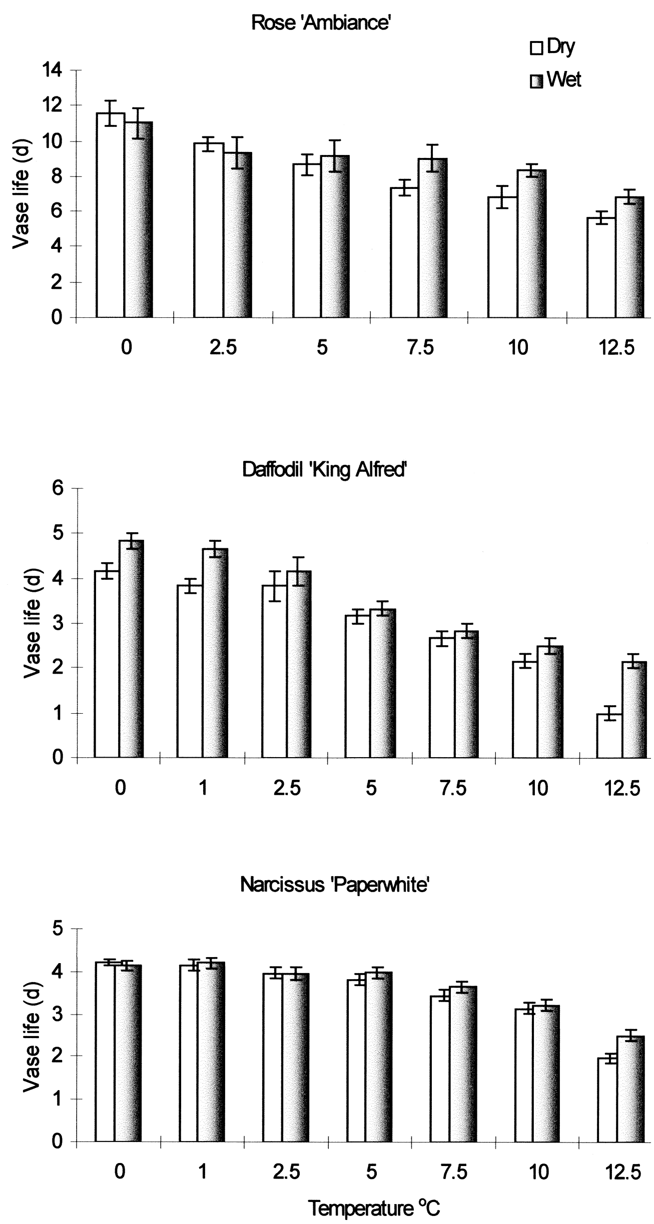

Fig. 1. Vase life of different flowers at 20 °C (68 °F) after 6 d of wet or dry storage at different temperatures. Error bars indicate the standard error of the means of six stems per treatment.

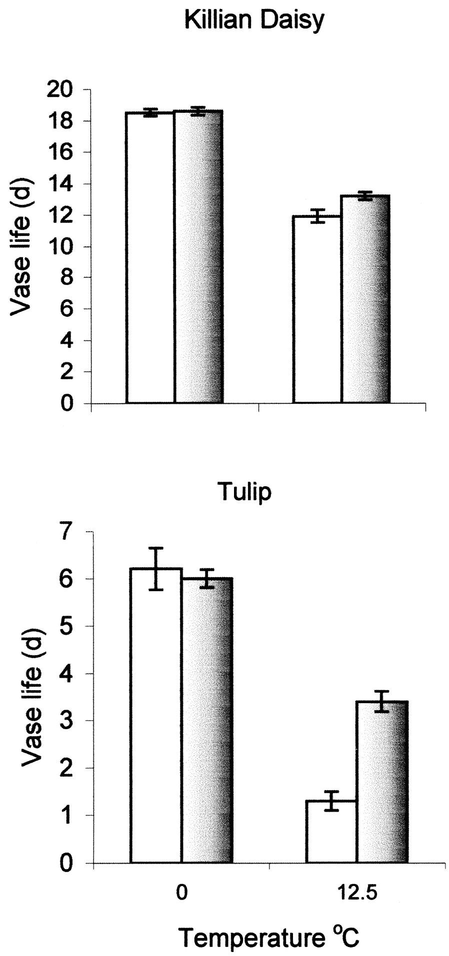

Fig. 2. Vase life of tulips and daisies at 20 °C (68 °F) after wet or dry storage at 0 or 12.5 °C (32 or 54.5 °F) for 6 d. Error bars indicate the standard error of the means of six stems per treatment.

companied by a substantial reduction in subsequent vase life. Iris flowers did not survive dry storage at 15 and 20 °C (Fig. 3).

~~Carnation 'Imperial White'~~ There were no significant differences in vase life (terminated by in-rolling of the petals and growth of the gynoecium) after wet or dry storage for carnation at 0, 5, and 10 °C (Fig. 3). Wet storage allowed carnation to be stored at 15 and 20 °C, but carnations did not survive dry storage at those temperatures (Fig. 3).

The data obtained in the present study support the hypothesis that the benefits of wet storage are only observed in cut flowers when they are held at warmer storage temperatures (above 10 °C). Nevertheless, the vase life after storage of all the cut flowers fell as the temperature during storage increased, whether the flowers were stored dry or in water (Figs 1, 2, and 3).

Previous researchers have examined the effects of dry and wet storage on the subsequent vase life of flowers, especially in cut carnations (Rudnicki et al. 1989). Wet storage is commonly recommended for storage periods of a few days (Hasegawa et al., 1976), while dry storage has been recommended for storage periods greater than 1 week. Goszczynska and Rudnicki (1982) successfully dry-stored bud-cut carnations for up to 6 months. However, De Hertogh and Springer (1977) found that iris kept better when stored wet, even for long periods. Additionally, Goszczynska et al. (1982) suggested that carnations harvested at commercial maturity performed better after cool storage if they had been held in water. Faragher et al. (1984) found that 'Mercedes' roses stored dry at 2.5 °C (36.5 °F) for 10 d did not show a significant reduction of the water content of the petals compared to roses stored wet. The consensus of these reports is that wet storage is not necessary to prevent water loss at low temperatures. The variable results from previous research may reflect differences in water loss during dry storage and/or the influence of other factors such as botrytis (*Botrytis* sp.) infection

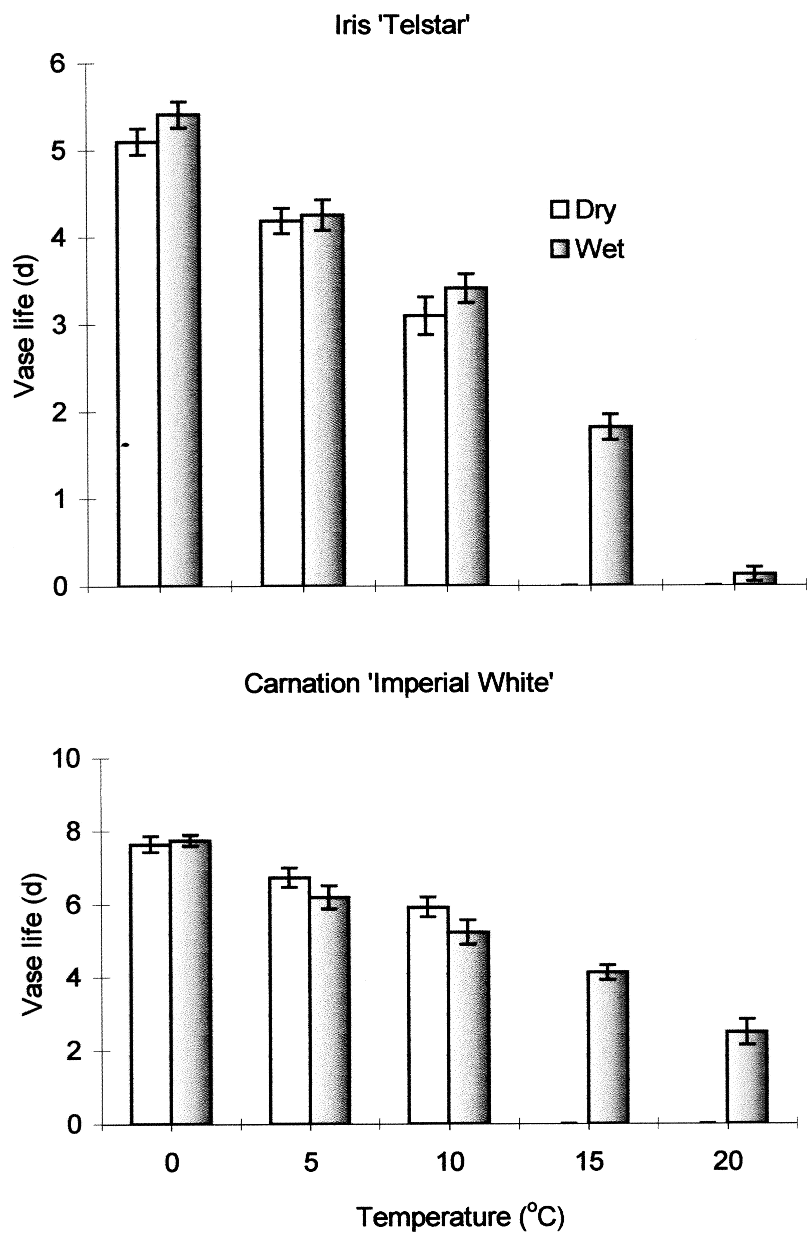

Fig. 3. Vase life of iris and carnations at 20 °C (68 °F) after wet or dry storage for 6 d at different temperatures. Error bars indicate the standard error of the means of 6 stems per treatment.

that may be influenced by the humidity of the storage environment.

In our experiments, we found that storage of flowers in water was beneficial only at temperatures above 10 °C. However, wet storage did not prevent the respiration-related loss of vase life during storage at higher temperatures. Considering the higher volume and weight of flowers transported wet, which translates into higher costs of transportation and handling, our data clearly indicate that the industry should continue to transport flowers dry and should minimize losses by paying closer attention to maintaining proper storage temperatures and relative humidities. In circumstances where warmer transportation temperatures are unavoidable, wet storage will provide insurance against desiccation, and some additional vase life.

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