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Interactions of Flower Stage, Cultivar, and Shipping Temperature and Duration Affect Pot Rose Performance

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Abstract. **Simulated shipping (storage) experiments were conducted to determine the effects of shipping temperature and duration on flower longevity and leaf abscission of pot rose *Rosa* L. 'Meijikatar' (= Orange Sunblaze) and 'Meirutral' (= Red Sunblaze). In addition, three flower stages (1 = tight bud, calyx not reflexing; 2 = showing color, calyx reflexing, no petals reflexed; 3 = full color, petals beginning to reflex, traditional bud stage) were selected immediately prior to storing plants at 4, 16, or 28 °C for 2, 4, or 6 days. The experiment was conducted during the summer and repeated during the winter. Evaluations were made in an interior environment at 21 °C for both experiments. 'Meirutral' exhibited longer poststorage longevity and less leaf abscission than 'Meijikatar' in both experiments. Flowers of both cultivars advanced by about one stage during storage at temperatures greater than 4 °C in summer, but developed more slowly in winter. Results from both experiments showed that plants stored at 4 °C had the longest poststorage floral longevity, the best flower quality, and the least leaf abscission, regardless of cultivar, storage duration, or flower stage at the beginning of storage. For plants stored at 16 °C, floral longevity decreased and leaf abscission increased when the duration was longer than 4 days. At 28 °C, flower longevity decreased and leaf abscission increased, especially at durations longer than 2 days. In the winter experiment, there was no leaf abscission on plants placed in the dark at 21 °C and watered during storage treatments lasting up to 6 days. In the summer experiment, the younger the flower, the more it was negatively affected by high storage temperature. Overall, poststorage floral longevity was longer in the summer than the winter experiment.**

Proper shipping temperature and duration are critical to maintaining the quality of flowering pot plants through the marketing period because each influences physiological processes that determine the quality and longevity of flowers and leaves. In general, flowering plants are more sensitive to high temperature injury than foliage plants and require lower shipping temperatures for good quality (Sterling and Molenaar, 1986). Flower bud, flower, and leaf abscission in potted *Hibiscus* were higher when shipping temperature was high (Thaxton et al., 1988). Shipping in darkness greatly reduced plant quality of calamondin (*Citrus*) (Ben-Jaacov et al., 1984) and *Hibiscus* (Gibbs et al., 1989). A shipping environment such as darkness or low light in combination with high temperature may induce and increase flower and leaf abscission (Decouteau and Craker, 1983; Rystedt, 1982a, 1982b; Vaughan and Bate, 1977). Also, the optimum shipping temperature is species-dependent. For example, *Hibiscus* and *Hippeastrum* should not be shipped at temperatures below 10 °C, while shipping at 4 °C is recommended for *Dendranthema* and *Lilium* (Nell, 1993).

Miniature rose cultivars for greenhouse pot plant culture have been introduced from Europe and are becoming more and more popular in the United States. One limiting factor for the commercial success of this crop is the ability to withstand adverse shipping conditions. Maxie et al. (1974) suggested that pot roses should be kept cool during shipping, but they monitored temperatures inside boxes during a simulated shipment that lasted for only a few hours; specific temperature and duration effects were not tested. In simulated shipping tests, postharvest flower bud and leaf abscission of traditional cultivars of pot rose were greater at high than at low temperature (Halevy and Kofranek, 1976). However, the effects of shipping duration were not studied. Nell and Noordegraaf (1991) showed that increasing shipping temperature and duration in simulated tests adversely affected the number of open flowers in an interior environment. Also, Clark et al. (1991) found that leaf chlorosis increased with increasing shipping temperature and duration. However, the effect of shipping conditions on flower senescence and abscission, or on the amount of time required for flowers to senesce or abscise, was not reported in either study. In addition, no reports are known to the authors concerning the specific effect of darkness during shipping on pot rose leaf abscission.

Stages of pot rose floral development were described by Cushman et al. (1994). However, the effect of floral stage of development at the start of the shipping period on pot rose flower longevity and floral development during shipping has not been reported.

For this report, flowers of two pot rose cultivars were classified as to stage of development when shipping was initiated, and were used to study the effects of shipping temperature and duration on floral longevity in an interior environment. Floral development during the shipping treatments was also quantified. In addition, the effects of shipping conditions on leaf abscission were monitored, and efforts were made to determine the specific effect of darkness during shipping on floral longevity and leaf abscission.

Materials and Methods

Summer protocol. Rosa L. 'Meijikatar' and 'Meirutral' rooted cuttings grown with one or two plants in 150-mL pots were received from the Conard-Pyle Co. (West Grove, Pa.) on 20 May and 16 June, respectively. The plants were potted into 550 mL round plastic pots using Metro-Mix 360 (Scotts Sierra Horticultural Products Co., Marysville, Ohio) and grown in a glasshouse under 30% shade and natural daylengths. Immediately after potting, Osmocote 14N–6.2P–11.6K (Scotts Sierra Horticultural Products Co., Marysville, Ohio) was surface-applied at 1.5 g per pot. Plants were fertilized weekly with 200 $mg \cdot L^{-1}$ N from Peter's 20N–8.9P–16.6K (Scotts Sierra Horticultural Products Co., Marysville, Ohio). On 5 July, after roots reached the bottom of the pots, all plants were cut back to 5 to 8 cm from the top of the medium and allowed to grow to flowering. This constitutes a short-cycle crop production schedule (Pemberton et al., 1997). The plants were re-randomized every 7 to 10 d in order to maintain uniformity. A 17 °C night temperature was maintained and four-stage fan and pad cooling began at 21 °C during

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the day. Average temperatures during the forcing period were 30 °C day and 21 °C night.

Simulated shipping (storage treatment) started on 31 July for 'Meijikatar' and 1 Aug. for 'Meirutral'. Immediately prior to storage, flower stages 1 (tight bud, calyx not reflexing), 2 (showing color, calyx reflexing, no petals reflexed), and 3 (full color, petals beginning to reflex, traditional bud stage) were identified and labeled so as to observe their development throughout the study (Cushman et al., 1994). At this time, all flowers were at stage 3 or earlier. The plants were well watered on the day of storage and the leaves were allowed to dry before sleeving. Six plants per treatment were chosen at random and five flowers of each stage were labeled randomly on the six plants.

The plants were sleeved with 10-cm paper sleeves and randomly placed into cardboard boxes measuring 47 × 47 × 41 cm. Holes, 5 cm in diameter, were cut at a height of 30 cm on the sides of the boxes to provide a total of 12 holes equally spaced around each box for ventilation. The boxes were placed in unlit, well-ventilated, controlled-temperature rooms to simulate shipping conditions.

Boxed plants were subjected to a factorial combination of storage conditions consisting of 4, 16, or 28 °C (±0.5) for 0, 2, 4, or 6 d. Subsequent to storage treatments, the plants were randomly placed in a simulated interior environment at 21 °C (±1 °C) under a continuous phtosynthetic photon flux (*PPF*) of 30 $\mu mol \cdot m^{-2} \cdot s^{-1}$ from cool-white fluorescent lamps. Nonstored control plants were placed in the interior directly from the glasshouse on the same day the other plants were placed in storage. All plants were watered as needed during the evaluation phase. At the end of the storage treatment, each designated flower was evaluated for poststorage stage. The stages used in addition to 1 through 3 (see above) were 4 (several petals reflexed, traditional exhibition stage), 5 (fully open), and 6 (postharvest life over, petal wilting or abscission) (Cushman et al., 1994). Flower development during storage was obtained by subtracting the flower stage at the beginning of storage from the poststorage stage. Each labeled flower was evaluated daily during the evaluation phase for floral longevity. Postharvest life ended when the flower abscised or reached stage 6. Poststorage floral longevity was obtained by deducting the day the plants were put into the interior room from the sequential day floral life ended.

Plants were also monitored during the interior phase and given poststorage (immediately after the end of simulated shipping), 7-d (7 d after the end of simulated shipping), and final leaf abscission ratings (day on which the plants stored for 6 d were given the 7-d abscission rating) based upon estimates of the proportion of the canopy that had abscised. Abscission was rated on a scale of 1 to 10: 10 = 0% to 10% abscission and 1 = 91% to 100% abscission. If leaf yellowing occurred, yellow leaves were included with the abscised leaves in assigning a rating, as they abscised quickly after turning yellow.

Winter protocol. Cultural practices, storage method and evaluation procedures were the same as the summer experiment with the following exceptions. Dormant plants of 'Meijikatar' and 'Meirutral' were shipped in 550-mL round pots (2 plants/pot) and received on 14 Dec. from the Conard-Pyle Co. Upon arrival, the plants were cut back to 5–8 cm in height, then grown to flowering in the same pots. This constitutes a long-cycle production schedule (Pemberton et al., 1997). The potting medium consisted of moss peat, vermiculite, bark, and perlite. Osmocote 14N–6.2P–11.6K was used at the same rate as in the summer experiment, and a two-feed and one-leach water schedule with 200 $mg \cdot L^{-1}$ N from Peter's 20N–8.9P–16.6K was followed throughout production. The glasshouse was heated to 15 °C at night. The average temperature was 21 °C day and 15 °C night during the growing period. Storage treatments started on 2 Feb. for 'Meirutral' and 13 Feb. for 'Meijikatar'.

Treatments were added in the winter experiment to isolate the effect of storage darkness on poststorage longevity. Plants were placed in the dark by covering them with cardboard shipping boxes in the interior environment (21 °C) for 0, 2, 4, or 6 d before exposure to light. They were watered as needed during and after treatment. The data were recorded as described above.

Statistical analysis. A completely randomized design was used. However, the inclusion of flower stage as a factor for all the flower data required a split-plot restriction to be placed on the analysis. The effects in the main plot involved storage duration, temperature, and cultivar, whereas the subplot consisted of the effects involving flower stage. Ideally, each flower stage would be chosen within each plant to ensure independence of the measurements, but all stages could not be found on each plant. Therefore, each flower stage was labeled at random within all the plants used in a particular treatment. Data for each treatment was averaged prior to analysis. This necessitated the use of the interaction storage duration × temperature × cultivar as Error A and the interaction storage duration × temperature × flower stage × cultivar as Error B. Floral longevity data were transformed using natural log for the summer experiment and natural log (x + 1) for the winter experiment (Steele and Torrie, 1980). Natural log (x + 1) was used for winter data because floral longevity was 0 in some treatments due to flower senescence or abscission during storage. Analysis of variance assumptions were checked (Little, 1985) for the rating data and no transformations were necessary.

The 0 d storage duration was the same for all temperatures, so that only one treatment was used for this combination of factor levels (Addelman, 1974). The appropriate sums of squares to use in SAS (SAS Institute, 1985) is the Type I sums of squares (C.E. Gates, personal communication). Error A (storage duration × temperature × cultivar) was tested for significance with Error B (storage duration × temperature × flower stage × cultivar); if *P* was greater than 0.25, the two error terms were pooled and used for testing the significance of all the effects (Bancroft, 1964). Polynomial analyses were used to determine the relationship of means to significant factor levels for effects involving quantitative variables. For qualitative variables, Duncan's multiple range test was used to separate the means. Leaf abscission data were analyzed using the same methods as described above for flower data except that no flower stage factor was involved.

Results

Summer experiment. For flower development during storage, the interaction between storage duration and flower stage at the beginning of storage was significant. Except for flower stages 1 and 3 stored for 2 d, flowers developed at least one stage (Table 1). Flower development increased with storage duration for flower stages 1 and 2, but storage duration did not affect development of stage 3 flowers. The interaction of storage duration, temperature, and cultivar was also significant (Table 1). At 4 °C, flowers developed little during 2 to 6 d of storage, but at 16 °C, flower development increased with storage duration for both cultivars. At 28 °C, flowers on 'Meijikatar' developed 2 stages or more regardless of storage duration, but flowers on 'Meirutral' developed more than 2 stages only after 4 d or more of storage.

Poststorage floral longevity of 'Meirutral' flowers averaged 2.9 d longer than that of 'Meijikatar' flowers, regardless of storage temperature or duration or flower stage at the beginning of storage (Table 2). In addition, the storage duration × temperature interaction was significant. Floral longevity did not differ when flowers were stored at 4 vs. 16 °C for 2 d (Fig. 1, Table 2). For flowers stored at 4 °C, floral longevity was similar regardless of storage duration, cultivar, or beginning flower stage. At 16 °C, floral longevity was similar after 2 and 4 d of storage, but decreased after 6 d; at 28 °C, floral longevity decreased after 4 and 6 d of storage.

There was also an interaction between temperature and flower stage. As storage temperature increased, floral longevity decreased for all flower stages (Fig. 2, Table 2). However, the younger the flower at the beginning of storage, the greater the effect of temperature. For flower stage 1, the difference in floral longevity between 4 °C vs. 28 °C was 12.9 d, whereas the difference was only 7 d for stage 3 flowers.

Poststorage leaf abscission ratings were not affected by treatment. The results for the 7-d and final ratings were similar, therefore only final ratings are reported. Leaf abscission was minimal on plants stored for 4 d or less regardless of the other factors (Table 3). However, after 6 d of storage, leaf abscission was almost 10%. More leaf abscission occurred in 'Meijikatar' than in 'Meirutral'; however, the storage temperature × cultivar interaction was significant (Table 3). As temperature increased, leaf abscission increased (the rating decreased) in 'Meijikatar', and the increase was linear,

Table 1. Floral development during storage of pot roses as affected by flower stage at the beginning of storage (beginning flower stage or BFS), temperature (Temp), cultivar (Cv), and storage duration (Time).

Beginning flower stage or cultivar	Temp (°C)	Floral development during storage (stage) Summer experiment Storage duration (d) 2	4	6	Winter experiment
Beginning flower stage[z]					
1	---	0.6 b[y]	1.1 a	1.3 ab	0.7 a
2	---	1.0 a	1.4 a	1.4 a	0.5 ab
3	---	0.8 ab	1.1 a	1.0 b	0.3 b
Cultivar					
Meijikatar	4	0.3	0.8	0.3	---
	16	1.0	1.1	1.5	---
	28	2.1	2.1	2.5	---
Meirutral	4	0.0	0.0	0.1	---
	16	0.3	0.7	0.9	---
	28	1.1	2.1	2.2	---
---	4	---	---	---	0.1
---	16	---	---	---	0.4
---	28	---	---	---	1.0
Significance			*F values*		
Temp		60.90**			30.39**
$Temp_L$		---			58.52**
$Temp_Q$		---			2.28[NS]
BFS		11.43**			22.63**
Other main effects were not of interest due to significant interactions.					
Time × BFS		3.05*			1.78[NS]
$Time_L$ was significant at $P < 0.01$ for BFS 1 and 2, but was NS for BFS 3.					
Time × Temp × Cv		5.56*			3.17[NS]
The $Time_Q \times Temp_L$ effect was significant at $P < 0.05$ for both cultivars.					
Other interaction effects were NS.					

[z]Stage 1 = tight bud, calyx not reflexing; stage 2 = showing color, calyx reflexing, no petals reflexed; stage 3 = full color, petals beginning to reflex, traditional bud stage; stage 4 = several petals reflexed, traditional exhibition stage; stage 5 = fully open; stage 6 = postharvest life over, petal wilting or abscission.
[y]Mean separation within columns and factors by Duncan's multiple range test at $P = 0.05$.
[NS, *, **]Nonsignificant or significant at $P = 0.05$ or 0.01, respectively.
[L, Q]Linear or quadratic, respectively.

Table 2. Seasonal cultivar response and analysis of variance summary for poststorage floral longevity of pot roses as affected by cultivar (Cv), flower stage at the beginning of storage (BFS), temperature (Temp), and storage duration (Time)[z]. Data were transformed using natural log prior to analysis.

Cultivar	Poststorage floral longevity (d) Summer experiment		Winter experiment
Meijikatar	14.9 b		6.9 b
Meirutral	17.8 a		16.2 a
Significance		*F values*	
Cv	36.10**		401.92**
Other main effects were not of interest due to significant interactions.			
Time × Temp	35.24**		255.25**
$Time_L \times Temp_L$	208.07**		101.10**
$Time_L \times Temp_Q$	13.88**		0.35[NS]
$Time_Q \times Temp_L$	3.39[NS]		1.44[NS]
$Time_Q \times Temp_Q$	2.22[NS]		3.80[NS]
Temp × BFS	3.80*		2.01[NS]
$Temp_Q$ was significant at $P < 0.01$ for all BFS.			
Other interaction effects were NS.			

[z]See Fig. 1 for effects of Time × Temp and Fig. 2 for effects of Temp × BFS.
[NS, *, **]Nonsignificant or significant at $P = 0.05$ or 0.01, respectively.
[L, Q]Linear or quadratic, respectively.

whereas temperature did not affect leaf abscission in 'Meirutral'. No leaf abscission occurred in the nonstored control plants.

Winter experiment. There were no significant interactions, so only main effects are presented in Table 1. Flower development during storage increased linearly with increasing temperature (Table 1). Again, the younger the flower stage at the beginning of storage, the more it developed during storage. There was no effect of storage duration or cultivar.

Poststorage floral longevity of 'Meirutral' flowers was 9.3 d longer than that of 'Meijikatar' regardless of storage temperature, storage duration, or flower stage (Table 2). The storage duration × temperature interaction was also significant. Generally, as temperature increased, floral longevity decreased (Fig. 1, Table 2). Longevity decreased greatly after 4 or 6 d of storage at 16 °C and 28 °C, but did not change with time at 4 °C. After storage in darkness at 21 °C, longevity was similar to that at 16 °C (data not shown).

In general, leaf abscission was more severe in winter than in summer, and neither storage temperature nor duration had an effect. However, severe leaf abscission occurred in some of the treatments within 7 d of interior maintenance. The final and 7-d leaf abscission ratings were similar, so only the final rating data are reported. More leaf abscission occurred in 'Meijikatar' than in 'Meirutral' regardless of storage treatment (Table 4). Interaction between storage duration and temperature was significant. Leaf abscission was negligible after storage at 4 °C regardless of duration (Table 4), but severe after storage at 16 °C for 6 d or at 28 °C for more than 2 d. No leaf abscission occurred on nonstored plants or on plants that were placed in the dark at 21 °C and watered as needed during the storage treatment (data not shown).

Discussion

Temperature is one of the most important factors affecting flower longevity and quality during shipping (Nell, 1993). Maxie et al. (1974) observed that abscission of unopened flower buds occurred in plants held at high air temperature in boxes exposed to sunlight during a 4-hour simulated shipping treatment. Halevy and Kofranek (1976) reported that the pot rose 'Pink Margo Koster' was strongly affected by temperature during simulated shipping. After 10 d in an interior environment, the end of the evaluation period, flower bud abscission was higher on plants shipped at 20 to 22 °C than on those shipped at 1 to 3 °C. Nell and Noordegraaf (1991) showed that increasing shipping temperature and duration adversely affected the number of open flowers in an interior environment. Results from our study indicate that simulated shipping at high temperature, especially for long durations, decreased pot rose flower longevity during poststorage evaluation. Flowers on plants of both cultivars exhibited the shortest longevity and poorest quality when stored at 28 °C for any duration or 16 °C for more than 2 d (Table 2, Fig. 1). Conversely, plants stored at 4 °C exhibited the greatest floral longevity and best flower quality. The lower longevity at high temperature was due to early flower abscission or wilting.

The interaction between flower stage at the beginning of shipping and shipping conditions for poststorage floral longevity has not been studied previously for pot roses. For the summer experiment, the younger the flower, the more affected it was by high storage temperature. However, there was no effect of flower stage on floral longevity in the winter experiment. The reason for these differences is unknown. Young rose flower buds have been used to study meiosis in pollen mother cells (Roberts, 1977). We know of no reference linking specific stages of flower development to male or female gametogenesis in rose, but an interaction between the stage of reproductive development and the growing environment could influence the sensitivity of young flower buds to adverse storage conditions.

The relationship between storage tempera-

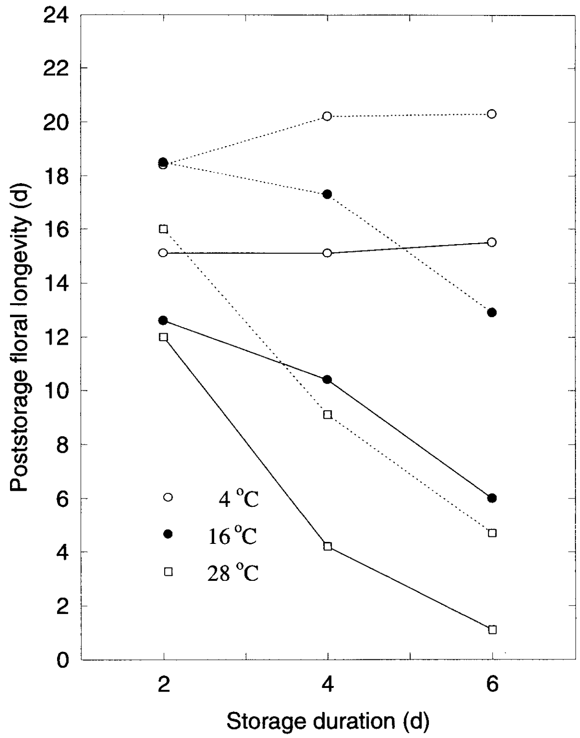

Fig. 1. Poststorage floral longevity as affected by the storage duration and temperature interaction that was significant for both the summer (- - - -) and winter (________) experiments. (See Table 2 for complete analysis of variance.)

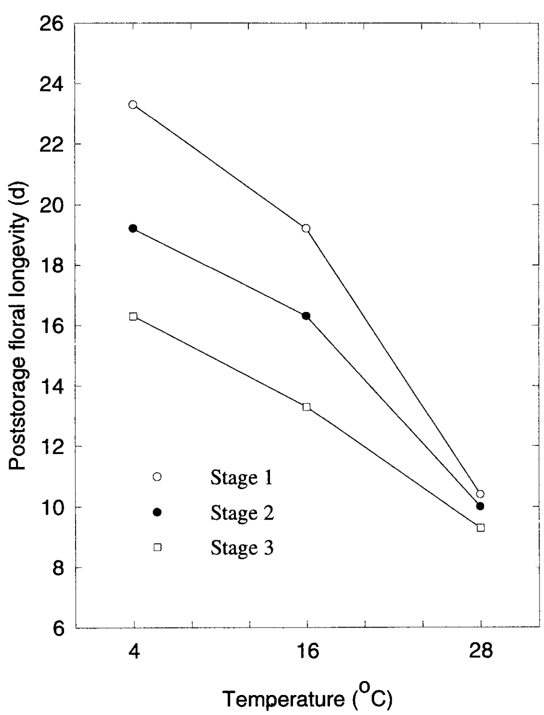

Fig. 2. Poststorage floral longevity as affected by the interaction between flower stage at the beginning of storage and storage temperature for the summer experiment. (See Table 2 for complete analysis of variance.)

ture and duration and poststorage floral longevity was similar in both experiments, but, overall, floral longevity was greater in the summer experiment. In growth chamber experiments, Kyalo et al. (1996) found that pot rose plants grown under high temperature and long day (HTLD) conditions exhibited greater poststorage floral longevity and plant shelf life than plants grown under low temperature and short day (LTSD) conditions. The environmental parameters used were designed to simulate summer-like and winter-like conditions in the HTLD and LTSD chambers, respectively. The differences in postharvest performance were attributed to differences in light quantity or temperature or both. However, whether these factors influence postharvest performance of pot roses independently or synergistically has not been determined, although a strong case for the influence of light can be made. One of the most important preharvest environmental conditions affecting the postharvest behavior of cut flowers is total light energy (Halevy and Mayak, 1979). Flowers produced during periods of low light intensity age more rapidly than those produced during periods of high light intensity. Flower longevity and quality were reduced when *Lilium* × 'Enchantment' was grown in a low light intensity greenhouse, although additional light was provided during the low-light months of January and November (Swart, 1980). In potted *Hibiscus rosa-sinensis* L., more flower buds abscised in response to dark storage when plants were grown under low than under high irradiance (Force et al., 1988). Supplemental lighting was not used in the present experiment, but is recommended for winter forcing of pot roses at higher latitudes (Pemberton et al., 1997). Flowering was adequate for the winter experiment, but floral longevity decreased rapidly under interior conditions. High intensity lighting may prove beneficial for improving flowering and postproduction quality in winter-forced crops even at lower latitudes (i.e., lat. 32°N, where the current work was done). Supplementary lighting increases the vase life and quality of cut roses (Fjeld et al., 1994). Further work in this area is warranted.

The influence of shipping conditions on floral development during simulated shipping has not been reported for pot roses. Usual commercial practice is to have at least one stage 3 flower (full color, petals beginning to reflex) on a plant for retailing (Pemberton et al., 1997). Results show that summer flowers will develop about one stage or more during storage at a temperature greater than 4 °C. Stage 3 flower development during storage will not be affected by duration, but flowers will open to stage 4 and subsequent longevity will be reduced. Stage 2 (buds just showing color) flowers can be expected to be at the proper stage of development for retailing after shipping. However, if storage is at 4 °C for up to 6 d for either cultivar, or at 16 °C for up to 2 d for 'Meirutral', flower development during storage will be slowed so that each pot should have at least one stage 3 flower prior to shipping for proper retailing. In winter, flower development during storage was slower. Stage 3 flowers could be shipped and the flowers would not open more than 0.4 stages during storage at 16 °C or less, so that the plants would be at a desirable stage for retailing.

Leaf abscission increased with both temperature and duration of exposure. Clark et al. (1991) found a similar response when measuring leaf chlorosis using simulated shipping conditions similar to those used in this study. In the dark, no photosynthesis occurs, and respiration increases with temperature. Generally, a combination of high temperature and darkness induces abscission in many plants (Millington and Chaney, 1973). However, the additional storage treatments in the winter

Table 3. The effects of storage duration (Time), cultivar (Cv), and temperature (Temp) on final leaf abscission rating for pot roses. Summer experiment.

Main effect	Temp (°C)	Final leaf abscission rating[z]
Time (d)		
0	---	9.8
2	---	9.7
4	---	9.8
6	---	9.2
Cultivar		
Meijikatar	4	9.8
	16	9.2
	28	8.5
Meirutral	4	10.0
	16	10.0
	28	9.8
Significance		*F values*
Time		7.27*
$Time_Q$ was significant at $P < 0.05$.		
Other main effects were not of interest due to significant interactions.		
Temp × Cv		8.60*
$Temp_L$ was significant for 'Meijikatar', but all effects were NS for 'Meirutral'.		
Other interaction effects were NS.		

[z]On a scale of 10, 10 = 0% to 10% abscission; 1 = 91% to 100% abscission

[NS, *, **]Nonsignificant or significant at $P = 0.05$ or 0.01, respectively.

[L, Q]Linear and quadratic, respectively.

Table 4. The effects of cultivar (Cv), temperature (Temp), and storage duration (Time) on final leaf abscission rating for pot roses. Winter experiment.

Main effect	Storage duration (d)	Final leaf abscission rating[z] (d)
Cultivar		
Meijikatar	---	7.8 b[y]
Meirutral	---	9.2 a
Temperature (°C)		
4	2	9.8
	4	10.0
	6	10.0
16	2	9.7
	4	9.2
	6	7.9
28	2	9.8
	4	6.4
	6	2.4
Significance		*F values*
Cv		11.80*
Other main effects were not of interest due to significant interactions.		
Time × Temp		8.60*
$Time_L \times Temp_L$ was significant at $P < 0.01$.		
Other interaction effects were NS.		

[z]On a scale of 10, 10 = 0% to 10% abscission; 1 = 91% to 100% abscission.

[y]Mean separation between cultivars by F test at $P = 0.05$.

[NS, *, **]Nonsignificant or significant at $P = 0.05$ or 0.01, respectively.

[L]Linear.

experiment showed that, at 21 °C, light did not affect leaf abscission. Leaf abscission increased after storage at 16 °C for 6 d with no added water, even though the plants did not appear dry or wilted after treatment. There was no abscission after 6 d of storage at 21 °C when the plants were watered as needed. Therefore, asymptomatic (i.e., lack of visible wilting) water stress could be involved in the observed responses to high temperature storage in the dark.

'Meirutral' exhibited greater poststorage floral longevity and less leaf abscission than 'Meijikatar'. Halevy and Kofranek (1976) reported 'Red Garnette' and 'Orange Margo Koster' had little bud and leaf abscission even at a warm "shipping" temperature (20 to 22 °C), while 'Pink Margo Koster' was severely affected. Clark et al. (1991) found differences in leaf chlorosis between cultivars in response to simulated shipping treatments. Also, Nell and Noordegraaf (1991) found cultivar differences in the number of open flowers in an interior environment in response to simulated shipping treatments. Selection of pot roses for postharvest longevity, therefore, appears warranted.

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