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Cooling of Potted Chrysanthemums[1]

George L. Staby[2]
Ohio Agricultural Research and Development Center, Wooster, OH 44691

J.F. Thompson and A.M. Kofranek[3]
University of California, Davis, CA 95616

Virginia R. Walter[4,5]
California Polytechnic State University, San Luis Obispo, CA 93407

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Abstract. Hydrocooling, forced air cooling, and hydrocooling plus forced air cooling techniques reduced the 7/8 mass mean cooling time of packaged potted chrysanthemums (*Chrysanthemum morifolium* Ramat.) by 57, 43, and 70%, respectively, compared to cooling under normal refrigeration. Mass mean 7/8 cooling time for plants in boxes with 0, 1 or 5 sides exposed to normal air movement in refrigerated storage was 49, 21 and 10 hours, respectively. Plants hydrocooled and stored at 2°C for 0, 5, or 10 days had equal postharvest longevity upon removal compared to plants cooled to 2°C in 60 hours and subsequently stored for the same periods. Plants stored at 22°C displayed equal postharvest longevity after 5 days of storage but were inferior after 10 days storage compared to rapidly cooled plants. Reasons for determining plants inferior varied according to cultivar.

The advantages of rapid cooling for many fruits and vegetables are well documented (5, 10, 12, 16, 17) and commercial implementation for these commodities is widespread. However, the use of rapid cooling techniques in the floral industry, specifically for cut flowers, has only recently been put into commercial use. To date, all such commercial floral cooling facilities are of the forced air type.

Research results regarding the cooling of cut flowers indicates that hydrocooling is not always advantageous (6-9, 11, 13-15) whereas vacuum (18-22) or forced air cooling (1-4) can extend product longevity. Similar research findings with potted floral crops are not available and are the objective of the present study.

'Paragon', 'Puritan', 'May Shoesmith' and 'Wild Honey' chrysanthemums were grown 5 or 7 cuttings ('May Shoesmith') per 15 cm pot using standard commercial cultural procedures. One week prior to harvest, plant grown in Salinas or Carpinteria, California were shipped to either San Luis Obispo or Davis, California, where they were placed in greenhouses until treatments were begun. The time period between arrival and initiation of treatments was an acclimation period under normal greenhouse conditions to minimize any effects of the transportation phase which was not related to any subsequent treatments. Plants were grown during the months of January through May.

Hydrocooling was accomplished by drenching only the medium with 0°C water of sufficient volume (about 1800 ml) to reduce the medium temperature to 2°. A 122 cm diameter axial flow fan powered by a 3/4 HP (560W) motor was used for the forced air cooling studies. Plants to be forced air cooled were sleeved in paper and packed 6 per box with 5% of the end walls removed to allow for sufficient air movement. Presently employed commercial forced air precooling technique, hereafter referred to as 'standard', was simulated by placing sleeved and boxed plants into 13° followed by 7° coolers, each for 1 day, followed by storage at 2° for the remaining time as indicated in the text. Room temperature storage ranged from 19-23°. Cooler rooms were maintained at ±0.5°C of the reported temperature. Mass mean temperatures were determined using thermocouples located in flower heads, stems, and medium and subsequently calculating a weighted average temperature based on the percentage of each component to the total weight at container field capacity.

The 7/8 mass mean cooling time is the period required to lower the mass mean temperature 7/8 of the temperature differential between the initial (harvest) temperature and the desired storage temperature.

Postharvest observations were made in rooms where the temperature ranged from 18-23° and 9 hr per day of Cool-White fluorescent illumination provided 1.35 klux of light at plant level. Plants were considered unacceptable when greater than 50% of the plants per pot exhibited one or more of the following characteristics: yellow leaves, brown flowers, wilted flowers or pathogen growth. In one experiment, a 3 member panel subjectively analyzed the plants over a 9 day period using a rating scale from 1 (best) to 10 (worst). Each panel member was considered a replication for analysis. Statistically, a randomized design was used with 1 pot (5 plants) used per replication and a total of 6 replications.

Plant cooling times required were reduced as the number of box surfaces exposed to normal cold room conditions was increased (Table 1). With 1/6 and 5/6 of the box surfaces exposed, cooling time was reduced by 57 and 78% respectively, compared to the 0/6 exposed surface treatment (a totally enclosed box).

Hydro and/or forced air precooling of 'Paragon' and 'Wild Honey' reduced the cooling time as compared to plants in boxes with 5/6 of the box surfaces exposed to normal cold room conditions (Table 2). The greatest reduction in cooling time (70%) was achieved when both hydrocooled and forced air cooling techniques were used. When these sleeved and boxed plants were subsequently stored for 6 days at 2°C and compared to sleeved and boxed plants stored at 20° for 2, 4, or 6 days, no postharvest quality differences were noted using a panel analysis.

Plant longevity generally declined as storage duration increased, especially for those plants stored at room temperature (Fig. 1). After 5 days of storage, hydrocooled, forced air, and non-precooled plants had similar longevities whereas after 10 days, those held at room temperature were greatly inferior. The 'standard' and hydrocooling treatments resulted in plants having similar longevities except for 'Puritan' where after 10 days storage the hydrocooling treatment reduced longevity. For all 3 cultivars reported in Fig. 1, statistically significant interactions between storage time and precooling method were present.

Table 1. Forced air precooling times of potted chrysanthemums as influenced by location within a stack.[z]

Surfaces exposed[x]	7/8 cooling time (hr) Stem	Medium	Air	Mass mean
0[y]	40	50	45	49.0
1[y]	21	21	21	21.0
5	3	11	7	10.2

[z]Six 15.5 cm pots/box sleeved with paper.
[y]Boxes were stacked 3 x 3 x 3 for 27 total boxes.
[x]No. of box surfaces exposed (out of 6 total) to freely moving air.

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[2]Professor, Horticulture. Mailing and reprint request address: Department of Horticulture, The Ohio State University, 2001 Fyffe Ct., Columbus, OH 43210.
[3]Extension Specialist, Agricultural Engineering and Professor, Environmental Horticulture.
[4]Assistant Professor, Ornamental Horticulture.
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Table 2. Mass mean cooling times of potted chrysanthemums as influenced by cooling methods.[z]

Precooling method		
Hydrocooling[y]	Forced air	7/8 cooling time (hr)
No	No	11.5
No	Yes	5.0
Yes	No	6.5
Yes	Yes	3.5

[z]All plants sleeved in paper, 6/box, with 5/6 of box sides exposed to normal cold room conditions at 1.7°C.
[y]1800 ml of 0°C water added to medium/15.5 cm pot within 2 min.

Reduced quality plants were manifested in 'Paragon' mainly by the white florets turning brown and/or flower wilting while the appearance of yellow leaves and/or wilted flowers were the main reasons 'Puritan' plants became unacceptable (Table 3). Plants affected by disease were mainly 'Paragon' stored for 5 or 10 days at room temperature. The pathogens involved were *Botrytis* and *Sclerotinia*.

Results presented in Tables 1 and 2 document the advantages in proper stacking or cooling method in rapidly attaining desirable storage temperature (2°C) of potted chrysanthemums. Box stacking patterns should allow at least one surface of each container to be exposed to freely moving air. In regard to cooling methods, one would expect that hydrocooling be faster than forced air since water is a more effective heat transfer medium than air. A lower 7/8 cooling time for hydrocooling would probably have been measured if the 0° water was added until the mass mean temperature was 0° and not 2°.

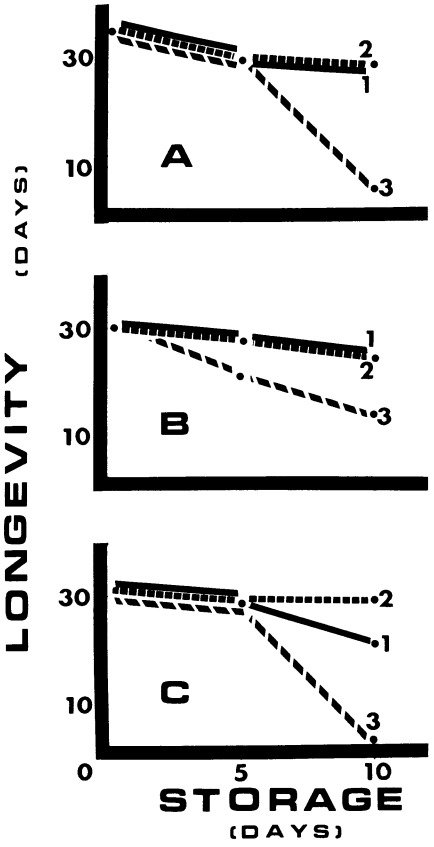

Fig. 1. Longevity of 'Paragon' (A), 'May Shoesmith' (B) and 'Puritan' (C) potted chrysanthemums stored, sleeved and boxed for 0, 5 or 10 days. Treatment no. are: 1 = hydrocooled to 2°C and placed immediately in 2° storage; 2 = 'standard' (cooled to 2° over a 60 hr period and then stored at 2°); 3 = no cooling and stored for entire time at a room temperature of 19-23°. HSD at the 5% level for A, B, and C were 5.6, 6.2, and 8.9, respectively.

Regardless of cooling method used, no postharvest quality advantages were noted with all cultivars tested compared to 'standard' refrigeration (slow cooling) procedures (Fig 1). More of the possible advantages of strict temperature management may have been noted if plants were harvested in warmer times of the year. Also, the fact that these plants are intact and continue to grow may affect some precooling advantages noted with fruits, vegetables (5, 10, 12, 16, 17) and cut flowers (1-4, 18-22.) The deleterious effect of hydrocooling on 'Puritan' after 10 day storage cannot be explained (Fig. 1). Possibly the roots were damaged by the sudden drop in temperature. In other unpublished results by the authors hydrocooling of the more temperature sensitive poinsettia plant did not result in negative symptoms suggesting that root chilling is not critical.

In conclusion, rapid cooling of potted chrysanthemums offers no advantages over 'standard' cooling procedures. In fact, for storage up to 5 or 6 days, low temperature storage and/or precooling of any sort did not result in higher quality plants compared to storage at 19-23°C for 'Paragon', 'Puritan', and 'Wild Honey'. Only 'May Shoesmith' responded favorably to low temperature treatments after 5 days of storage while 'Puritan', 'Paragon', and 'May Shoesmith' responded well to these treatments after 10 days compared to 19-23° storage. Hence, the commercial recommendation would be to use low temperature storage only if the plants will not be unpacked and exposed to reasonable home or store environments within about 5 days.

Table 3. Reasons for determining potted chrysanthemum plants inferior as influenced by storage, time, temperature, and cultivar.

Treatment		Frequency (%)					
Storage time (days)	Cooling	Yellow leaves	Brown flowers	Wilted flowers	Diseased plants	Brown + wilted flowers	Yellow leaves + wilted flowers
				Paragon			
0	None	0	50	33	0	17	0
0	Standard	0	100	0	0	0	0
0	Hydro	0	87	0	0	17	0
mean		0	79	11	0	11	0
5	None	0	33	0	17	50	0
5	Standard	0	50	17	0	33	0
5	Hydro	0	67	0	0	33	0
mean		0	52	6	6	39	0
10	None	0	0	0	100	0	0
10	Standard	0	100	0	0	0	0
10	Hydro	0	83	17	0	0	0
mean		0	61	6	33	0	0
grand mean		0	64	7	13	17	0
				Puritan			
0	None	17	0	33	0	0	50
0	Standard	67	0	0	0	0	33
0	Hydro	0	0	33	0	0	67
mean		28	0	22	0	0	50
5	None	67	0	0	17	0	17
5	Standard	17	0	0	0	0	83
5	Hydro	33	0	17	0	0	50
mean		39	0	6	6	0	50
10	None	100	0	0	0	0	0
10	Standard	0	0	67	0	0	33
10	Hydro	67	0	33	0	0	0
mean		56	0	33	0	0	11
grand mean		41	0	20	2	0	37

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Response of *Freesia hybrida* Corms to Exogenous Growth Regulator Applications[1]

T.L. Gilbertson-Ferriss[2] and H.F. Wilkins[3]
Department of Horticultural Science and Landscape Architecture, University of Minnesota, St. Paul, MN 55108

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Abstract. Vacuum infusion or soaking of freshly harvested *Freesia hybrida* Bailey 'Moya' corms in solutions of ethephon, gibberellic acid (GA_3), abscisic acid (ABA), benzylamino purine (BA) or indole-acetic acid (IAA), or in solutions with combinations of these growth regulators, did not decrease the time required for shoot emergence. Ethephon delayed shoot emergence and acted synergistically when combined with GA_3, or with GA_3 and BA, to further delay shoot emergence. Ethephon or ethephon + BA treatments increased the number of shoots produced per corm. Days to flower and flower quality were not influenced by any of the exogenous growth regulator treatments. Presently, there appears to be little horticultural advantage in applying these growth regulators to freesia corms to hasten shoot emergence prior to planting in order to circumvent the need for 10 to 13 week storage treatment at 28°C to remove dormancy and to ensure rapid shoot emergence.

Historically, recently harvested *Freesia hybrida* corms have required a 10 to 13 week storage treatment at 28-31°C to insure rapid shoot emergence when replanted (15). An increase in the number of possible crop rotations per year in a greenhouse would be possible if this time span of 13 weeks could be reduced or replaced by a growth regulator treatment. Further, more rapid generation cycles in a breeding program could result if the storage period were shortened.

Previous attempts to promote rapid freesia corm emergence by exogenous growth regulators have had varying degrees of success. BA treatments on elongated terminal shoots broke apical dominance but the corms had poor root development and unsatisfactory shoot development (13; Susumee Yazawa, personal communication). Resoaking these previously BA treated corms in a GA_3 solution stimulated shoot growth. Addition of naphthaleneacetic acid (NAA) to the BA treatment resulted in maintenance of apical dominance and promoted better root growth. No data were given regarding the influence of these exogenous growth regulator treatments on subsequent flowering.

In another study (9) freesia corms which were recently harvested and soaked in calcium cyanamide (CA) or BA solutions required fewer mean days for shoot emergence with 119.8 for the control and 101.8 or 115.5 days for the respective treatments. Treatment of CA or BA increased the percentage of corms that flowered by 15% over the water soak control. Though not specified, it appears from the photographs that *F. refracta alba* was used in these experiments.

Objectives of this study were to evaluate 2 methods (vacuum infusion vs. soaking) of applying exogenous growth regulators to *Freesia hybrida* corms and to evaluate their influence on shoot emergence as on well as subsequent flowering.

'Moya' corms were forced the previous season for flower production in a glass greenhouse, foliage allowed to mature, and then harvested June 10, 1978, in The Netherlands. The source (M.C. van Staaveren, Aalsmeer) stated that the soil temperature at harvest was 21°C. Corms were dried, cleaned, graded (average weight + 7.0 g/corm) and stored at 6° according to standard commercial procedures. The air freight shipment left on July 6, 1978, and arrived at the University

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[2]Assistant Professor, Department of Plant and Earth Science, University of Wisconsin-River Falls, River Falls, WI 54022. (Previously, Graduate Research Assistant, Department of Horticultural Science and Landscape Architecture, University of Minnesota, St. Paul, MN 55108.)
[3]Professor of Horticulture, Department of Horticultural Science and Landscape Architecture, University of Minnesota, St. Paul, MN 55108.