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Postharvest Characteristics of Poinsettias as Influenced by Handling and Storage Procedures[1]

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Abstract. **Sleeved poinsettia plants (*Euphorbia pulcherrima,* Willd. cvs. Annette Hegg Supreme and Annette Hegg Dark Red) stored best at 10°C. Lower temperatures (2-7°C) induced chilling damages as manifested mainly by bract blueing. Higher temperatures (up to 16°) resulted in increased leaf petiole epinasty and bract drooping. The bract blueing and leaf petiole epinasty disorders became worse as storage duration increased from 2 to 10 days, while bract drooping decreased during this same period. Plants sleeved and stored in paper were generally of higher quality upon removal than those sleeved and stored in plastic. Under relatively static conditions (15m/minute air speed), poinsettias froze at about −4°. Sleeving poinsettias delayed low-temperature damage. The injury of sleeved poinsettias was related to temperature, air speed, and exposure time which can be estimated by: time to injury (minutes) = 3.94 × chill factor (°C) + 61.9.**

Increased sales of poinsettia plants through non-traditional retail outlets has heightened awareness of postharvest problems due to increased storage times, extended sales period, longer transportation distances and an influx of inexperienced poinsettia producers and retailers. Yet, there is only limited data available concerning the care and handling of poinsettias. For example, out of about 2200 compiled articles on the postharvest care and handling of floral crops, 31 refer to poinsettias and few present experimental results *per se.* One major exception to this lack of research in extending poinsettia longevity is the breeding that led to the introduction of the first longer lasting cultivar 'Paul Mikkelsen' (19).

While referring to stock plants, an early report stressed the importance of maintaining "warm" temp during transit to prevent injury, however, no specific temp was reported (1). Subsequent reports contained similar statements for finished plants with minimum recommended temp ranging from 10 to 18°C (5, 6, 12, 17, 24). Freezing point data ranged from −1.1 to −2.2° (25). Exposure of poinsettias to 10°C for 60 to 120 min induced droopy bracts, a response that was accentuated as exposure time increased, varied among cultivars tested and was prevented if the pots were insulated (12). The droopy bract and/or an epinastic leaf response also have been attributed to ethylene as a result of sleeve-induced mechanical stress (23) or to storage in non-ventilated areas (14). However, the increased ethylene evolution could only be shown using excised petioles and not by intact plants when the plants were sleeved (23). Exogenous ethylene applications from 5 to 10 ppm for 24 to 72 hr induced epinasty (10 and Marousky, F. J., personal communication, 1978) as did various synthetic auxins (4). Also supporting a possible role of ethylene is the reduction of leaf drooping with $AgNO_3$ sprays (Larson, R. A., personal communication, 1978), an antagonist of ethylene action.

Since the introduction of longer lasting poinsettia cultivars (19), leaf and/or bract abscission problems have been reduced but not eliminated. Attempts to delay abscission using growth regulators have been successful using auxins (4, 10) and cytokinins (16), while gibberellins, abscisic acid and ethylene had little or no effects (10). Ethylene chlorohydrin and carbon tetrachloride vapors as well as ammonium thiocyanate dusts promoted abscission (9). However, in this latter study it was determined that the so-called "abscission layer" which ordinarily develops prior to natural leaf or bract fall does not form when induced by the 3 chemicals noted. Insufficient light also enhances abscission (24).

Endogenous auxin levels are higher in longer lasting poinsettia cultivars and decrease over time from harvest while H_2O_2 and IAA-oxidase levels increase (11). Hence, relative auxin levels as mediated by synthesis, destruction and/or transport controls have been suggested as regulating abscission.

Long-term storage potential of potted floral plants would be desirable as time in the marketing channels increases. However, studies with poinsettias in packages developed for storage showed poor quality plants after 3 weeks at 20°C (22).

As a result of the above documented and empirical data, it is generally suggested that poinsettia plants be sleeved for a minimum time and be stored at temp ⩾ 10°C. This research was initiated to obtain data on the effects of sleeves, and storage temp and durations on postharvest poinsettia quality in an attempt to clarify previous statements in the literature.

Materials and Methods

'Annette Hegg Dark Red' and 'Annette Hegg Supreme' poinsettias were grown using standard cultural procedures at the Paul Ecke Poinsettia Ranch, Encinitas, and Sunnyside Nurseries, Salinas, Calif., respectively. 'Annette Hegg Dark Red' plants were grown as single stemmed plants, 3 per 15 cm plastic pot in a medium of 1 soil: 3 composted redwood sawdust: 8 sphagnum peat moss: 8 perlite with Osmocote 19-6-12 (19N–2.6P–10.0K) added at 4.4g/liter. No growth regulators were applied. The plants were scheduled to flower on Dec. 15, 1977 at which time they were paper sleeved, boxed, transported by air the same day to the Univ. of California, Davis, unpacked immediately, and placed into a 17°C greenhouse until used in the study.

The 'Annette Hegg Supreme' plants were grown in a 1 soil: 4 perlite: 4 sphagnum peat moss medium, with 1 plant per 15 cm plastic pot but were pinched to yield an average of 5-8

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blooms per plant. Succinic acid-2,2-dimethylhydrazide (daminozide) as a 7500 ppm spray was applied once before pinching. At the scheduled flowering date of Dec. 1, 1977, plants were sleeved either in paper (high wet strength, 20.4 kg), plastic (1.25 mil high density neutral polyethylene) or fiber (spun-woven polyester known as Fibe-Air) and transported by truck to Davis the same day where treatments were begun immediately or unpacked and placed into a 17°C greenhouse until needed. Storage temp were ± 0.5°C from the set temp. For the low temp-air speed studies, a 370 W, 91 cm diam propellor-type ventilation fan was altered to obtain the desired air speeds as measured by a vane anemometer. The fan was located in a cooler where the temp could be regulated between −7 to −2°C. Six plants were used per treatment.

After treatments were imposed, plants were observed in a 16-24°C room having 9 hr/day of about 1.3 klx cool-white fluorescent light at plant level. Plants were continuously subirrigated using deionized water. Daily postharvest observations were made of characteristics such as epinastic leaf petioles and bract drooping, blueing and/or bleaching. Epinasty is defined in this study as when a petiole exhibits bending in more than 1 direction, similar to twisting as in 2,4-D-induced injury. Bract drooping is a positive geotropic response and is similar to a wilted appearance. Bract blueing is noted to be interveinal, beginning as scattered blue-colored blotches and subsequently merging together depending on treatments imposed. Red bracts which faded or became pinkish are referred to as "bleached" bracts.

Results

The occurrence of epinastic leaf petioles was influenced equally by sleeve type after 5 days of storage or slightly accentuated with plastic sleeves after 10 days (Table 1). Leaf epinasty was lacking at 1.7°C, lacking or very minimal at 7.2° while it was extensive at 12.8°, regardless of storage duration. After 5 days storage, bract damage was less when paper sleeves were used but was equal with all sleeve types after 10 days. Bract damage developed to a greater extent at the 2 lower temp with 1.7° being much worse after 5 days than 7.2°. Subjective visual observations, in addition to the data presented in Table 1, always suggested that plastic sleeves resulted in reduced quality plants compared to either fiber or paper sleeves. Paper sleeves resulted in the least damage and loss of quality of the 3 types tested.

Exposing plants to greater temp variations with only paper sleeves showed that leaf epinasty generally increased as temp increased from 7.2 to 15.6°C and as storage duration increased from 2 to 6 days (Table 2). However, plants partially or completely recovered from the epinastic conditions as time increased after removal (Table 3). The number of droopy bracts also increased as temp increased but decreased after 2 storage days in contrast to that noted with epinastic leaf petioles (Table 2). Bract damage only occurred at the lowest temp (7.2°C) after > 2 storage days and increased as storage time increased.

Of primary concern in marketing poinsettias in cold climates is the protection of plants from exposure to low temp. Initial experiments showed that sleeving poinsettias in paper retarded the rate at which plant temp decreased when exposed to low temp (Fig. 1). Exposing similarily sleeved plants to various chill factors (chill factor in °C = $°C-(33-°C)\sqrt{\text{vel. (m/sec.)}/7}$) and time periods showed which time-chill factor combinations resulted in damaged plants as manifested by bleached and/or frozen bracts (Table 4). Bract damage was greater as chill factors decreased and exposure times increased. By determining those time-chill factor combinations that resulted in damage and calculating a regression equation (Fig. 2), it was now possible to estimate the combination at which injury would occur. With an $r^2 = 0.93$, the equation is: time to injury (min) =

Table 1. Postharvest condition of 'Annette Hegg Supreme' poinsettias at removal from storage.

Treatment	5 day storage: Epinastic leaf petioles (%)[z]	5 day storage: Damaged bracts (no./plant)	10 day storage: Epinastic leaf petioles (no./plant)	10 day storage: Damaged bracts (no./plant)
Sleeve				
Paper	33	2.4	1.7	6.2
Plastic	33	6.2	2.5	6.2
Fiber	33	4.8	1.7	5.1
Temp (°C)				
1.7	0	11.4	0.0	7.6
7.2	0	2.0	0.2	7.6
12.8	100	0.0	5.7	2.3
SE	--	1.5	0.7	0.5

[z]% plants exhibiting at least 1 epinastic petiole.

Table 2. Postharvest condition of 'Annette Hegg Dark Red' poinsettias at removal from storage.[z]

Storage temp (°C)	Defect (no. per pot of 3 plants): Epinastic leaf petioles	Droopy bracts	Blue bracts
	2 day storage		
7.2	0.7	3.3	0
10.0	1.3	8.0	0
12.8	1.0	9.7	0
15.6	5.3	12.0	0
Mean	2.1	8.3	0
	4 day storage		
7.2	1.0	2.3	9.0
10.0	0.7	1.0	0
12.8	8.7	4.3	0
15.6	3.0	7.7	0
Mean	3.4	3.8	2.3
	6 day storage		
7.2	4.0	5.0	14.7
10.0	7.0	1.3	0
12.8	7.0	2.7	0
15.6	7.7	6.0	0
Mean	6.3	3.8	3.7
SE	0.63	0.94	–

[z]Plants stored in paper sleeves.

Table 3. Epinastic leaf petioles of 'Annette Hegg Dark Red' poinsettias as influenced by storage temp and days after removal.

Storage temp (°C)	Epinastic leaf petioles (no. per pot of 3 plants)[z] Days after removal: 0	2	4	6	Mean
7.2	1.9	0.4	0.4	0.2	0.7
10.0	3.0	1.7	1.2	0.6	1.6
12.8	5.6	3.7	1.4	0.9	2.9
15.6	5.3	4.1	2.8	1.7	3.5
Mean	4.0	2.5	1.5	0.9	

[z]SE = 0.24

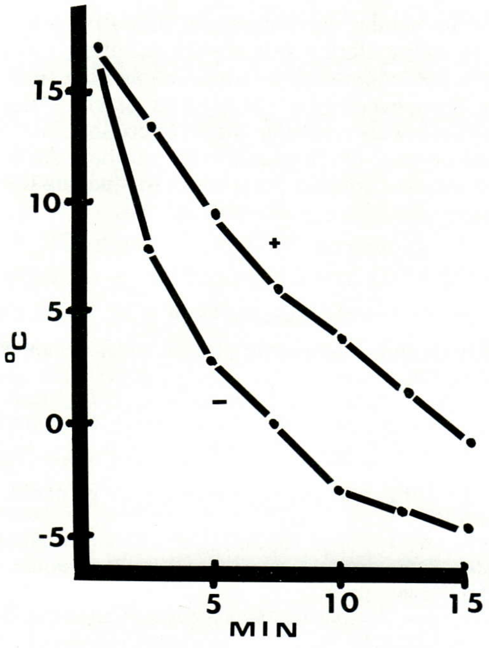

Fig. 1. Comparison of + and – paper sleeves on stem temp of 'Annette Hegg Supreme' poinsettias exposed to –3.9°C and 15m/min air speed for various time periods.

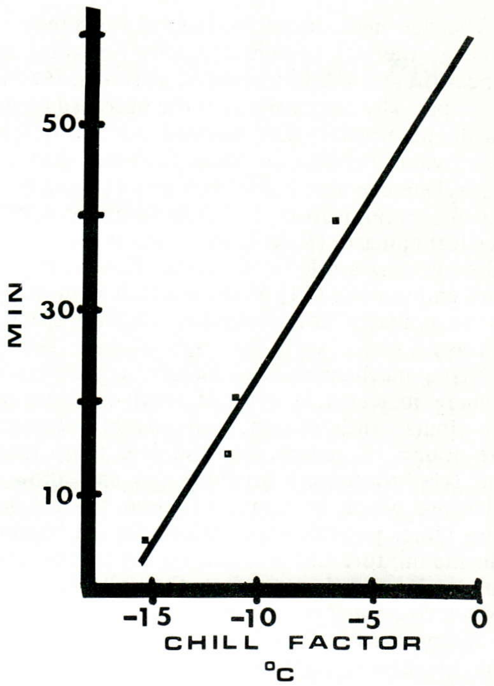

Fig. 2. Linear regression model for predicting the time it takes to injure a sleeved poinsettia plant exposed to various chill factors and times by the equation: Injury time (min) = 3.94 × chill factor (°C) + 61.9.

3.94 × chill factor (°C) + 61.9.

During these exposure studies, it was noted consistently that bracts and leaves froze in a temp range from –4.4 to –3.9°C in relatively calm air speeds of about 15m/min (data not presented). Actual thermocouple measurements of the heat of fusion and/or visible tissue collapse were used as parameters for measuring plant freezing.

Discussion

The practical implications of the storage data suggest that poinsettia plants should be stored for a minimum time in paper sleeves at 10°C (Tables 1 and 2). Upon removal from storage, plants should be unsleeved and allowed to partially recover from leaf epinastic conditions (Table 3). Some previous data regarding storage duration and temp generally agree with these findings (24) while others suggest storage temp from 2.8 to 5.7° higher than 10° (5, 6, 12, 17). Most of these higher temp recommendations were determined using older cultivars, which are known to have thicker bracts and larger petioles and, hence, possibly less subject to leaf epinasty. 'Eckespoint C-1' is an example of this type while the 'Hegg' cultivars are generally thinner.

For short term storage (viz. < 2 days), 7.2°C may indeed be the best temp because of the lack of or reduced leaf epinasty (Tables 1 and 2), reduced droopy bracts and no blue-colored bracts (Table 2). In fact, it may be possible to store poinsettias for longer periods at temp ⩽ 7.2° if they are conditioned by exposing them to temp slightly above the chilling temp (viz. 7.2° to about 9°) for a relatively short period of time before exposure to chilling temp of ⩽ 7.2°. This phenomenon has been demonstrated using many fruits and vegetables (13) and would have to be tested for poinsettias. Another approach could utilize periodic rewarming of the plants during low temp storage to reduce chilling injury, a practice which is effective for various fruits and vegetables (13). Practical commercial observations made in Florida support this concept. During certain winters, temp can frequently go substantially below 7.2° for a number of consecutive nights with no resultant blue bracts, possibly because of rewarming during the warmer day temp (A. Rosacker, personal communication, 1978).

The physiological mechanism for leaf epinasty may be due to an auxin-ethylene interaction. Specifically, it is known that mechanical stress can influence auxin transport and ethylene production (20) and could account for leaf epinasty in poinsettias. Whether the mechanical stress of sleeving inhibits basipetal and/or lateral auxin transport (18) directly by causing an increased auxin level at the stress site, or it is a redistribution of the auxin at the site, or it stimulates ethylene formation which in turn inhibits auxin transport, is not known. However, other data suggest that ethylene-induced epinasty is not dependent on IAA transport or its redistribution within the petiole

Table 4. Damage of 'Annette Hegg Supreme' poinsettias at various chill factors.

Treatments: Exposure time (min)	Treatments: Chill factor (°C)	Bract damage (no./plant): Bleached	Bract damage (no./plant): Frozen
10	–6.4	0	0
20	–6.4	0	0
40	–6.4[z]	19	0
10	–10.2	0	0
20	–10.2[z]	12	0
40	–10.2	39	26
15	–10.7[z]	6	0
30	–10.7	39	0
60	–10.7	43	0
5	–15.2[z]	22	0
20	–15.2	43	14
40	–15.2	83	45

[z]Treatments which first resulted in damaged bracts.

(15, 21). The sleeving-induced mechanical stress may be further complicated by the lack of light generally prevailing in storage. This absence of light is also known to alter auxin levels (7) and thus may be partially responsible for the observed epinasty. It is known with poinsettias that stressed excised petioles have enhanced ethylene production levels (23) and that exogenous levels of ethylene can also induce epinasty (10 and F. J. Marousky, personal communication, 1978). In addition, $AgNO_3$ sprays can reduce leaf epinasty (R.A. Larson, personal communication, 1978), all suggesting a role for ethylene. Finally, the exogenous (4, 10) and endogenous (11) auxin research with poinsettias as it relates to epinasty and abscission suggests specific auxin-mediated roles.

The blueing mechansim may be similar to that with rose flowers where increases in cell pH result in more blue color (2). Since similar anthocyanins and possibly flavonol co-pigments are found in poinsettias, the low temp may disrupt membrane (viz. tonoplast) integrity (8) and allow cell constituent leakage which in turn could alter sap pH and hence, bract color. Other possible explanations for the blueing include changes in the mixture and amounts of the anthocyanins themselves, to co-pigmentations, and to the colloidal condition of certain other components of the cell sap (3). This blue color generally disappeared in 2 or 3 days after removal from storage (data not presented) suggesting that the co-pigments were metabolized.

Since the droopy bract data did not parallel the leaf epinasty data with regard to storage duration (Table 2), one may suggest that is is a different physiological system as implied by earlier research (12). In this earlier work, exposure of poinsettia plants to 10°C for only 60 to 120 min promoted droopy bracts to some degree. While difficult to make direct comparisons, our data may support these findings in that the shortest exposure time (2 days) resulted in the most droopy bracts, regardless of temp. Possibly, this response can be induced after short (1 or 2 hr) induction periods and subsequently the plants may acclimate gradually to the new environment with a concomitant reduction of droopiness. However, the low temp exposure trials presented in Table 4 and Fig. 1 and 2 plus other unpublished data (viz. hydrocooling the growing medium to 2°C) seldom if ever resulted in plants exhibiting droopy bracts.

An important conclusion that can be drawn from the low temp exposure data (Table 4, Figs. 1 and 2) is that poinsettias are more tolerant to low temp stress than many reports suggested (1, 5, 6, 12, 17, 24). Additionally, plant sleeving has a significant practical advantage of protecting plants from low temp injury, probably by reducing heat transfer.

By relating chill factor versus exposure time to the point at which a sleeved poinsettia plant is damaged (Table 4 and Fig. 2), there now exists a feasible method of approximating when such plants are in danger of injury when being transported at any phase of marketing. For example, a retailer can obtain the expected minimum chill factor daily from the local weather service, apply the formula and subsequently suggests measures to ensure that customers can safely transport the plants to their homes in a reasonable time. The chill factor concept is applicable strictly to animals that maintain constant body temp. The concept was used to convey the combined effects of air speed and temp on heat loss.

While not a major objective of this study, it was determined that poinsettias froze at a temp of about −4°C which is somewhat lower than those previously reported, ranging from −1.1 to −2.2° (25). Possible techniques and/or cultivar differences may account for these differences, viz. may have frozen at higher temp if exposed to them for longer times.

In conclusion, the data presented in this study are for 2 poinsettia cultivars only and do not consider possible response variations in other cultivars, which are known to react very differently to similar environmental stimuli. Care should be observed in extrapolating our results to other cultivars. Difficultities were encountered when comparing leaf epinasty and bract drooping results obtained in previous studies since these parameters were seldom uniformly described, viz. "droopy" to one author may be "epinastic" to another. At the present time there are no common parameters for judging the injury of poinsettias.

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