Retention of ascorbic acid often is used as an indication of all nutrient retention, and there is belief that other nutrients, being more stable than ascorbic acid, are less affected during storage (4). Flavor of 'Murcott' remained acceptable in fruit subjected to cold treatment during storage for 40 days. The loss of flavor or development of stale flavor in 'Murcott' after 26 days at 4.4°C is difficult to explain. On the contrary, in 'Valencia' the flavor was acceptable in cold treated fruit stored at 4.4°C and there was a negative change in flavor when they were moved to 21.1°. This indicated that post cold treatment warming of 'Valenica' is an important factor in its fruit quality.

Cartons used for packing fruit subjected to cold treatment may lose their strength because of moisture absorption when transferred to 21.1°C. The high moisture content of these cartons was caused by condensation of moisture on fruit when they were moved from 4.4° to 21.1°. When a 2-tier stacking system was used during storage, the top portion of the bottom tier of cartons and the bottom portion of the upper-tier became damp. This was due to the percolation of condensed water from the surface of fruit in boxes from upper layers. In order to avoid the weakening of boxes, fruit must be conditioned gradually to ambient temperature, or strong cartons must be employed for packing fruit. Condensation of moisture on the surface of fruit also is not desirable if fruit is to be fumigated with hydrogen cyanide as required in Japan for disinfestation of scale insects and mites, since the solubility of this gas in water may cause injury to the fruit peel.

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Development of Drought-stressed Poinsettias

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Abstract. **Single stem *Euphorbia pulcherrima* Willd. cv. Eckespoint C-1 Red were exposed to single or repeated episodes of drought stress to leaf water potentials of −1.0 or −1.3 MPa at different times during crop development. Decreased plant height and delayed flowering generally were caused by treatments including stress prior to time of initial bract coloration. Plant quality was reduced by those treatments that inhibited bract development and caused leaf abscission. Inflorescence diameter was reduced the most by stress after bract coloration. Bract dry weight was sensitive to stress and was reduced by stress between the time of initiating long nights and bract coloration. Leaf abscission resulted from a single exposure to −1.3 MPa after flower initiation. Stress prior to start of long nights had little effect on plant development.**

Drought stress of poinsettias was used as a means of height control in some commercial operations prior to the advent of growth retardants (11). A side effect of this practice was reduced inflorescence size and increased leaf abscission. Research with other crops has shown drought stress to cause reduced rates of growth, reduced organ size, and organ abscission (5, 8). The response to drought stress may vary with level of stress and stage of crop development (2, 7). Research on poinsettia water relations has found that growth retardants caused reduced transpiration rates (3) and total crop irrigation requirements (4), but that drought stress had less effect on development of growth-retardant-treated plants than it had on nontreated ones (4). This report describes the development of poinsettias exposed to 2 levels of drought stress at different stages of crop development.

Materials and Methods

Plant materials and general procedures. Rooted 'Eckespoint C-1 Red' poinsettia cuttings were obtained from a commercial propagator and planted 1 per 15-cm pot in Metro Mix 500 (W.R. Grace Co., Cambridge, Mass.). N, P, and K were applied weekly at 0.50, 0.23, and 0.46 g, respectively, per liter irrigation water. Spacing between plants provided 0.17 m^2 per plant. Chlormequat was applied 2 weeks after planting at 0.53 g per pot as a 180-ml soil drench. Developing laterals were removed to maintain single stem plants. Poinsettias were main-

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tained vegetative for 4 to 5 weeks with incandescent lighting between 2200 and 0200 HR. Flower initiation then was induced by covering plants with black cloth from 1700 to 0800 HR until anthesis. Plants were irrigated by hand as required to maintain a moist medium except during prescribed stress periods.

Time is presented relative to 1st long night. The day after the 1st long night was day 1 and the day prior to that night was day −1. Stress periods, such as −21 to 1, indicate the last day water was applied and the day on which normal irrigation was resumed. Plants were stressed until leaf water potentials were −1.0 ± 0.1 or −1.3 ± 0.1 MPa as measured with a pressure chamber.

Experiments were arranged in randomized complete block designs with 6–10 plants per treatment in each of 3 replications. Half the plants in each treatment were used to monitor changes in water potential, while the remaining plants were used for data collection. At termination, total bract dry weight, inflorescence diameter (mean of 2 measurements) leaf number, leaf area, days to anthesis (day one to day of 1st protrusion of stamens), and plant height (top of propagation cube to base of secondary cyathia) were determined. Leaf number included leaves and transitional bracts at nodes below the inflorescence. Total bract dry weight included bracts and transitional bracts below the inflorescence. Data were subjected to analysis of variance, and Dunnett's test was used to separate means different from nonstressed controls at 5% and 1% levels.

Expt. 1. Plants potted in Jan. 1981 were grown in a polyethylene-covered greenhouse with 1200 μmol $s^{-1}m^{-2}$ maximum photosynthetic photon flux density and relative humidities of 35% to 65%. Temperatures ranged from 17° to 27° C. Drought stress was initiated on day −14, −2, 10, 22, or 34. Irrigation was resumed when plants reached the prescribed stress level of -1.0 or -1.3 MPa.

Expt. 2. Plants potted in Mar. 1981 were grown in a glass greenhouse with minimum and maximum temperatures of 18° and 33°C, respectively. Maximum photosynthetic photon flux density was 1000 μmol $s^{-1}m^{-2}$ and relative humidity ranged from 40% to 65%. Stress periods were −21 to 1, 1 to 25, 25 to 51, −21 to 25, or 1 to 51. Water was withheld on the 1st day of the stress period, and when −1.0 or −1.3 MPa was reached, plants were irrigated and again allowed to dry. This process was repeated until the end of the stress period and is described as repeated stress episodes.

Expt. 3. Plants potted in Dec. 1981 were grown in a glass greenhouse with maximum photosynthetic photon flux density of 1300 μmol $s^{-1}m^{-2}$, relative humidities of 40% to 70%, and temperatures between 19° and 31°C. Plants were subjected to −1.0 MPa as a single stress episode, as in Expt. 1, starting on day 26 or 35 or as repeated episodes, as in Expt. 2, starting day 26 and ending 49. Expt. 3 was repeated using plants potted in Feb. 1982. Plants were treated as described except that stress to −1.3 MPa was included along with the −1.0 MPa treatments.

Results

Expt. 1. The only single stress episode that caused a large reduction in final plant height was stress to -1.3 MPa starting on day −2 (Table 1). The day −14 stress treatments and stress to −1 MPa, starting day −2, reduced plant elongation by the end of the stress periods; however by the end of the experiment these plants were only slightly shorter than the nonstressed plants. The −1.3 MPa stress starting on day −2 caused a 6-day delay in time to anthesis. Anthesis for plants in other treatments occurred within 3 days of the nonstressed plants.

Bract quality, as indicated by bract dry weight and inflorescence diameter, was reduced only by −1.3 MPa stress started on day 10, 22, or 34. Also, plants in these 3 treatments had a reduced number of leaves on plants at anthesis due to leaf abscission. Plants in the −1.3 MPa at day −2 treatment had the same number of leaves as the nonstressed plants but a reduction in total leaf area, which indicated that stress reduced leaf enlargement. Leaf expansion is one of the components of crop development most sensitive to drought stress (5).

Expt. 2. Repeated stress to −1.0 MPa from day 1 to 25 and both levels from day −21 to 25 and 1 to 51 resulted in plants shorter than nonstressed plants (Table 2). The number of days to anthesis was less variable than in Expt. 1, but the 2-day difference for plants exposed to -1.3 MPa from day −21 to 1, 1 to 25, −21 to 25, and 1 to 51 was significant ($P < 1\%$).

Bract dry weight was reduced by all treatments except stress imposed from day −21 to 1. However, plants in treatments that included stress during the last period of crop development, day 25 to 51 and day 1 to 51, had the lowest bract dry weights and smallest inflorescence diameters. Also, plants in these treatments had the fewest leaves remaining at anthesis. Plants stressed to −1.0 MPa from day 1 to 25 and to both levels from −21 to 25 had final leaf areas significantly ($P < 5\%$) less than nonstressed plants, while the number of leaves were similar.

Expt. 3. Plants were given single episodes of stress starting day 26 or 35 and repeated episodes from 26 to 49. None of the treatments had a discernable effect on time to anthesis or plant height. Bract dry weight was reduced by all treatments, but repeated exposure to stress had the greatest effect on bract dry weight and inflorescence diameter (Table 3). All treatments caused leaf abscission, with repeated stress causing over 85% of the leaves to abscise.

Discussion

The alterations in poinsettia development resulting from drought stress in this study depended upon the stage of development in which stress occurred. Initial signs of poinsettia flower initiation occur at about 8 to 10 days after start of long nights (10). First signs of bract coloration occurred at about day 25 in these studies, and anthesis occurred at about day 50.

Final plant height was reduced only by treatments that included stress between start of long nights and bract coloration (Tables 1 and 2). The greatest stem elongation rate for plants in Expt. 1 and 2 occurred during this period: 4.3 mm day^{-1} vs. 1.8 and 3.0 mm day^{-1} for the periods prior to long nights and after bract coloration, respectively. Thus, 70% of total shoot elongation on nonstressed plants developed between start of long nights and bract coloration. Stress prior to long nights reduced elongation during that period, but the rapid growth that followed allowed stressed plants to obtain a height only slightly shorter than nonstressed plants at flowering. White and Holcomb (11) reported that stressing plants repeatedly to the point of wilting prior to irrigation for a 48-day period following planting reduced plant height by 50%. Our treatment most similar to theirs, the day −21 to 25 repeated stress in Expt. 2, reduced height by only 18%. Plants in White and Holcomb's (11) studies were not treated with a growth retardant as were ours. This treatment is a possible cause for the discrepancy, since drought stress does not reduce elongation in growth-retardant-treated plants to the extent it does in nontreated plants (4). Also, there could have been differences in the degree of stress between the 2 studies.

Drought stress increased the time to anthesis most when imposed prior to bract coloration (Tables 1 and 2). Aspinall and

Table 1. Development of 'Eckespoint C-1 Red' poinsettias exposed to a single drought episode at different times.

Stress Period[z]	Level (MPa)	Plant ht (cm)	Days to anthesis	Bract dry wt (g)	Inflorescence diam (cm)	Leaf area (cm^2)	Leaves remaining
Nonstressed		26	49	3.8	45	929	14
−14 to 1	−1.0	24	51	4.0	47	931	14
−14 to 5	−1.3	25	52	4.1	47	953	14
−2 to 7	−1.0	24	51	3.4	44	821	14
−2 to 15	−1.3	21**[y]	55**	3.3	44	707	14
10 to 18	−1.0	26	49	3.8	45	907	14
10 to 24	−1.3	27	51	2.5**	39	586**	9**
22 to 30	−1.0	27	49	3.6	43	945	14
22 to 37	−1.3	26	50	1.8**	34**	328**	5**
34 to 42	−1.0	25	49	3.6	44	869	14
34 to 47	−1.3	25	49	2.0**	34**	202**	4**

[z]Last day of regular irrigation to day regular irrigation resumed. Day 1 was day after 1st long night.
[y]Indicates difference between nonstressed and treatment means at 5% (*) and 1% level (**), respectively, by Dunnett's test.

Table 2. Development of 'Eckespoint C-1 Red' poinsettias exposed to repeated drought episodes at different times.

Stress Period[z]	Level (MPa)	Plant ht (cm)	Days to anthesis	Bract dry wt (g)	Inflorescence diam (cm)	Leaf area (cm^2)	Leaves remaining
Nonstressed		34	48	5.4	47	1800	17
−21 to 1	−1.0	33	48	5.4	48	1555	16
−21 to 1	−1.3	33	50**	4.8	49	1563	16
1 to 25	−1.0	31[y]**	48	4.7*	44	1320**	16
1 to 25	−1.3	33	50**	4.4**	46	1634	18
25 to 51	−1.0	33	48	3.9**	39*	1609	15
25 to 51	−1.3	33	49	3.2**	36**	1508	13**
−21 to 25	−1.0	28**	49	4.2**	42	1217**	16
−21 to 25	−1.3	28**	50**	4.6*	48	1356**	16
1 to 51	−1.0	28**	49	3.4**	37**	1162**	14*
1 to 51	−1.3	27**	50**	2.9**	34**	1120**	13**

[z]Last day of regular irrigation to day regular irrigation resumed. In between, plants were allowed to dry to level indicated and then irrigated and allowed to dry again. Day 1 was after 1st long night.
[y]Indicates difference between nonstressed and treatment means at 5% (*) and 1% (**) level, respectively, by Dunnett's test.

Table 3. Development of 'Eckespoint C-1 Red' poinsettias exposed to single or repeated drought episodes at different times.

Stress Period[z]	Level (MPa)	Bract dry wt (g)	Inflorescence diam (cm)	Leaves remaining
Nonstressed		5.2[y]	40	16
26 to 36	−1.0 S[x]	3.1**[w]	35	10**
35 to 45	−1.0 S	3.9**	36	10**
26 to 49	−1.0 R	2.5**	30*	2**

[z]Last day of regular irrigation to day regular irrigation resumed. Day 1 was day after 1st long night.
[y]Each bract dry weight mean is significantly different ($P < 5\%$) from others by Duncan's test.
[x]Single (S) and repeated (R) drought episodes, respectively.
[w]Indicates difference between nonstressed and treatment means at 5% (*) and 1% (**) level, respectively, by Dunnett's test.

Husain (1) reported that drought stress suppressed floral initiation in *Pharbitis nil* and *Lolium temulentum* and suggested this suppression was due to reduced translocation of the flowering stimulus from leaves. However, the delayed anthesis we observed could be due to slowed cell division and enlargement in stressed plants.

Plant quality was affected most by stress that caused leaf abscission or a reduction in inflorescence size. These effects did not occur with stress treatments applied only prior to long nights and flower initiation. Stress between bract coloration and flowering generally had more detrimental effects than stress between start of long nights and bract coloration (Tables 1 and 2). Bract dry weight, was more sensitive to stress than was inflorescence diameter (Tables 1–3). Stress was applied during the first half or last half of the period between bract coloration and anthesis in Expt. 3, but there appeared to be little difference in plant response during those periods, except that stress during the first half resulted in a greater reduction in bract dry weight.

Leaf abscission in poinsettias was more sensitive to stress after flower initiation than before initiation (Tables 1 and 2). This response may be due to leaf age (6,9). However, because there were only a few days between stress episodes that had dramatically different results in Expt. 1 (Table 1), the difference may have been due to physiological changes during flower initiation rather than leaf age.

The level and duration of stress affected plant response. Single stress episodes to −1.3 MPa caused several changes in plant development not caused by stress to −1.0 MPa in Expt. 1. However, when repeated stress episodes were employed in Expt. 2, the differences between the 2 levels were not as distinct. Also, single episodes to −1.0 MPa caused changes in development to a greater extent in Expt. 3 than in Expt. 1. However, there was a long cloudy period while plants were being stressed in Expt. 3, which resulted in the length of the stress period being 2 days longer than in Expt. 1. Expt. 3 was repeated during a clear period using a greenhouse with increased light levels. The length of the stress periods were only 4 and 6 days for stress to −1.0 and −1.3 MPa, and these short duration stress treatments caused little effect on plant development.

Midday water potentials for well-watered plants in these studies were between −0.7 and −0.6 MPa. Irrigation regimes designed to conserve water by reducing irrigation frequency will cause reduced water potentials and may not be useful with poinsettias because of the narrow range between well-watered conditions and stress levels which cause reduction in crop quality. This type of irrigation regime would be least likely to have detrimental effects early in the crop period.

Consistent with other species, poinsettia responds differently to drought stress depending on stage of development. Plant height and time of flowering were affected most by stress occurring during the middle of the production cycle. Inflorescence size is affected most by stress while the bracts are enlarging, and vegetative plants are less subject to leaf abscission than are reproductive plants.

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Calcium and Magnesium Requirements of *Ilex crenata* 'Helleri'

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Abstract. **Rooted cuttings of *Ilex crenata* Thunb. 'Helleri' were grown in sand culture with varied Ca and Mg levels in a factorial experiment. No increase in total dry weight was achieved by increasing Ca or Mg rates above 5–10 ppm. Necrosis of shoot apices occurred at 0 ppm Ca. The tissue level of Ca required for optimal growth (0.23–0.38%) was lower than has been reported for broadleaf evergreens. In a 2nd experiment with pine bark, Ca was supplied at 0 and 120 ppm and Mg at 0 and 60 ppm. No differences in dry weight due to added Ca and Mg were observed. In a 3rd experiment, the influence of dolomitic limestone (0, 2, 4, and 8 kg m^{-3}) and gypsum (1 and 2 kg m^{-3}), added to pine bark, on Ca and Mg availability over time was determined. The addition of dolomitic limestone increased Ca and Mg in the growing medium solution, but unamended bark supplied both elements in quantities sufficient for growth of *I. crenata* 'Helleri'. The addition of gypsum caused a large initial increase in Ca in the growing medium solution, but levels dropped precipitously thereafter.**

Data documenting levels of Ca and Mg required for optimum growth of container-grown woody ornamentals are limited. One recommendation states the saturated extract for a container medium should possess 80–200 ppm Ca as an "acceptable" level, with 200–350 ppm being considered "optimum" (4). Recommendations for Mg are 35–60 ppm as "acceptable" and 75–100 ppm as "optimum" in the saturated medium extract (4).

Dunham and Tatnall (5) grew *I. crenata* 'Convexa' in a ¾ sand and ¼ German peatmoss mixture. Dry weight was greatest when Ca was supplied at 1–10 ppm in the nutrient solution. Brewer (1) grew *I. crenata* 'Green Island' in sand culture and determined 90 ppm Mg to be the level needed to achieve optimum growth. Edwards and Horton (7) grew peach seedlings in

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