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Factors Influencing Premature Cyathia Abscission in Poinsettia 'Annette Hegg Dark Red'

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Abstract. **Low irradiance levels, high temperatures, and water stress all promoted premature cyathia abscission in poinsettia 'Annette Hegg Dark Red' (*Euphorbia pulcherrima* Willd.). Abscission was greater in plants placed under 75% shade at 16°C night temperature (NT) than on plants placed under normal daylight (ND) at 16° or 21° NT. Water stress (0.6 MPa) promoted abscission on plants grown at an 18° NT and ND but did not promote abscission on plants grown at 16° NT and ND or on under 75% shade (13° to 21° NT). As plant density increased, transmission of photosynthetically active radiation (PAR) through the bracts to the leaf canopy decreased while cyathia abscission increased concomitantly. More than 90% of the PAR above the bracts was absorbed or reflected 5 cm below the bracts on 20 cm tall plants spaced at 65 or more plants m^{-2}. Reducing natural irradiation 75% by shading leaves of poinsettia promoted cyathia abscission, whereas removing immature bracts decreased abscission. Leaf removal on plants with intact bracts promoted abscission to a degree that 100% of the cyathia abscised prior to anthesis, whereas bract removal on plants with intact leaves resulted in only 23% abscission of the cyathia 25 days after first anthesis. Measurements of nonsoluble carbohydrate showed a significant increase in leaf carbohydrate on plants with bracts removed while carbohydrate decreased in leaves of plants with bracts intact. Carbohydrate depletion appears to be the primary factor responsible for premature cyathia abscission in poinsettia.**

Premature poinsettia cyathia abscission ("center drop"), defined as the abscission of the poinsettia cyathia prior to normal marketing, can be a major problem for poinsettia growers in the midwest and northeastern United States. Abscission of the cyathia can occur either before anthesis (preanthesis) or after anthesis (postanthesis). While not effecting growers every year, economic losses can be significant when the problem occurs. Entire truck loads of poinsettias have been rejected by buyers when cyathia abscission was found in the shipment (William H. Carlson, personal communication).

Preanthesis cyathia abscission has been observed on plants grown in the greenhouse under low irradiance levels (50% shade) (21), and on plants placed in a controlled environment under low irradiance and high temperatures before the bracts had completely developed (21, 27). Postanthesis cyathia abscission has been observed on plants placed in postharvest environments (17, 18, 21), and on plants held in dark storage (17, 18). The longer the dark storage, the greater the abscission.

It has been shown that photosynthesis is reduced in source

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leaves under low irradiance levels, thereby reducing the amount of carbohydrate available for translocation to developing sinks (1). Also, covering flowers and pods of soybean reduced their sink strength and promoted abscission (7). Competition between sinks can cause the younger, less developed sinks to abscise (3, 5, 22). In cultivars that bear a small number of flowers of fruit, there is less abscission than in heavy bearing cultivars (2, 22, 24, 28).

In preliminary experiments, low irradiance levels, high night temperatures late in crop development (finishing temperature), and water stress promoted cyathia abscission (Miller and Heins, unpublished data). Ethylene at 10 μl l^{-1} for up to 7 days had no effect on abscission when applied at anthesis. Chemical sprays at anthesis of napthalene acetic acid, 6-benzylamino purine (BA), or silver thiosulphate did not prevent abscission. However, gibberellic acid (GA_3) or Promaline (GA_4 + GA_7 + BA) (Abbott Laboratories, N. Chicago, Ill.) prevented abscission, as previously reported (20), but resulted in undesirable plant quality when applied at anthesis and delayed flowering when applied early in crop development.

The objective of the studies reported in this paper was to determine how environmental and physiological factors influenced cyathia abscission in poinsettia.

Materials and Methods

General conditions. Rooted cuttings of 'Annette Hegg Dark Red' (AHDR) were received on various dates from Paul Ecke Poinsettias, Encinitas, Calif. (Table 1). One cutting was planted per 10 cm plastic pot (an experimental unit) in VSP medium (Michigan Peat Co., Houston, Texas) composed of 2 peat : 1 perlite : 1 vermiculite (by volume) amended with dolomitic limestone, superphosphate, and trace elements. Plants were fertilized with 260 mg l^{-1} N, 130 mg l^{-1} K, and 0.1 mg l^{-1} Mo. Chloromequat (2-chloroethyl trimethylammonium chloride) was applied at 1500 mg l^{-1} as a foliar spray for height control on the dates indicated in Table 1.

Greenhouse experiments. Plants were placed in a glass greenhouse and grown single stem at a spacing of 33 plants m^{-2} under normal daylight (ND) for 1 week (Expt. 1, 3) or were grown for 2 weeks under ND plus a 4 hr night interruption (2200 HR to 0200 HR) of 5 μmol $s^{-1}m^{-2}$ photosynthetically active radiation (PAR) from 60 W incandescent lamps (General Electric Co., Cleveland, Ohio) (Expt. 4–7). Short days (SD) were started as indicated in Table 1 and were provided by pulling black sateen cloth over the plants from 1600 HR to 0800 HR daily. The initial night temperature (NT) was 18°C. Day temperature (DT) and venting temperatures were 3° and 6° above the NT, respectively, in all experiments regardless of NT. Night temperatures were lowered to 16° during the first 2 weeks of SD. Plants were then moved to different greenhouse sections depending on experimental temperature.

Table 1. Dates rooted cuttings of 'Annette Hegg Dark Red' poinsettia were received and potted, when short days were initiated and chlormequat (2-xhloroethyl trimethylammonium chloride) applied for Expt. 1–7.

Experiment	Cuttings received and potted	Start short days	Chlormequat[z] applied
	1983		
1	25 Aug.	1 Sept.	1 Sept.
			8 Sept.
			22 Sept.
2	25 Aug.	9 Sept.	2 Sept.
			9 Sept.
3	25 Aug.	1 Sept.	1 Sept.
			9 Sept.
4	25 Aug.	1 Sept.	1 Sept.
			9 Sept.
5	22 Sept.	1 Oct.	8 Oct.
	1984		
6	25 Jan.	8 Feb.	15 Feb.
			22 Feb.
7	25 Jan.	8 Feb.	15 Feb.
			22 Feb.

[z]1500 mg l^{-1} foliar spray.

Expt. 1: Irradiance, temperature, and water stress. Two weeks after the start of SD, plants were placed at initial temperatures of 16°C or 18° NT. All plants then were grown for an additional 4 weeks. Plants were moved from the 16° or 18° initial temperature houses to greenhouses with NT of 13°, 16°, 18°, or 21°. Plants were kept at these finishing temperatures through completion of data collection. For each finishing temperature, half of the plants remained under ND and half were placed under 75% shade. In all temperature and irradiance treatments, half of the plants were water stressed repeatedly to a plant water potential of −0.6 MPa, the other half were watered daily to maintain a water potential of about 0.0 MPa. Plant water potential was measured using a pressure bomb (PMS Instrument Co., Corvallis, Ore.). Ten extra plants were used per treatment to take water potential readings, with an average of 2 plants used each time a reading was taken. The same 2 plants were not used again. When the average water potential was about −0.6 MPa, all plants in the corresponding treatment were watered to container capacity. The water stress treatment plants were stressed repeatedly until all plants in a treatment reached anthesis. The number of times plants were stressed prior to anthesis varied from 2 to 5, depending on irradiance and finishing temperature.

The experiment was analyzed as a completely randomized split-split-split plot design, with initial temperature as the main plot, and final temperature, irradiance, and water stress, as subplot factors. There were 32 treatments (2 initial temperatures x 4 finishing temperatures x 2 irradiance levels x 2 water stresses), with 10 plants per treatment.

Expt. 2: Controlled environment irradiance and temperature experiment. After planting as described for the greenhouse experiments, equal numbers of plants were placed in 2 controlled environment chambers and grown single stem at a spacing of 33 plants m^{-2} for 2 weeks under 125 μmol $s^{-1}m^{-2}$ PAR (0600 HR to 2200 HR) from 215 W VHO cool-while fluorescent lamps (Sylvania Lighting Corp., Danvers, Mass.) Short days were started 9 Sept., with plants exposed to an 8 hr light span from 0800 HR to 1600 HR daily.

The initial NT was 18°C. At the start of SD the NT was lowered to 16° in one chamber and raised to 21° in the other chamber. Plants remained at 16° or 22° for 3 weeks when one-third of the plants at 16° were moved from 16° to 21° and one-third of the plants at 21° were moved from 21° to 16°. Plants were finished at the new temperatures. Similarly, after 5 weeks of SD, another 3rd of the plants were moved between chambers, with the remaining 3rd of the plants grown continuously at 16° or 21°. Plants remained in respective chambers during data collection.

The experiment was analyzed as a completely randomized 2 × 3 factorial design. There were 6 treatments (2 temperatures, 3 moving times), with 10 plants per treatment.

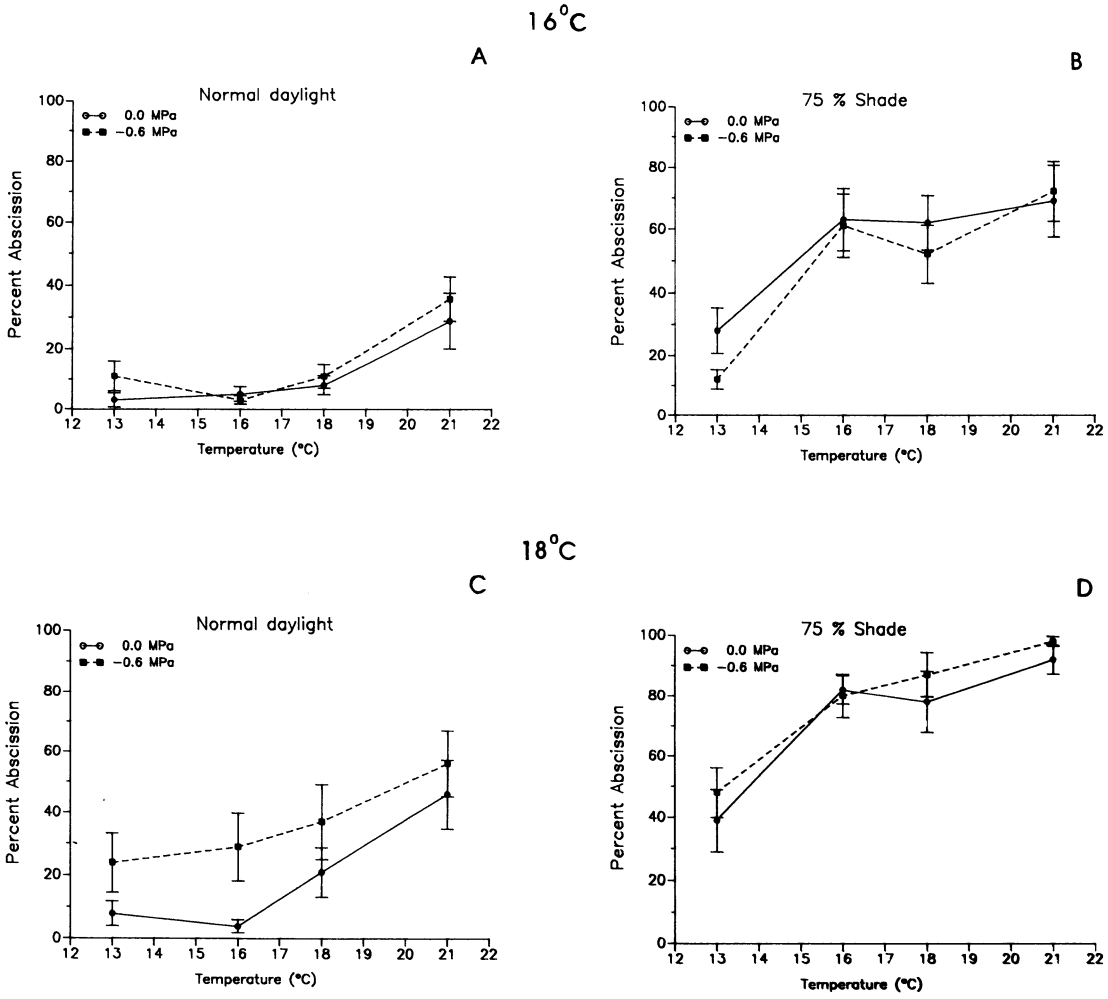

Fig. 1. Mean percentage of cyathia abscission 70 days (10 weeks) after the start of short days (SD) for poinsettia 'Annette Hegg Dark Red' initially grown at 16° or 18°C night temperature (NT) under normal daylight (ND) from 0 to 6 weeks after the start of SD. Plants then were placed under ND or 75% shade at 13°, 16°, 18°, or 21° NT. Half of the plants at each temperature and irradiance treatment were water stressed to about −0.6 MPa, the other half were not water stressed (about 0.0 MPa). Vertical bars represent 1 SE. Expt. 1.

Expt. 3: Cyathia shading. Plants were initially grown for 5 weeks in the greenhouse under SD at 16°C NT. After 5, 6, or 8 weeks of SD, the inflorescence on a group of plants was covered with aluminum foil. One group of plants was left as a control. The experiment was analyzed as a completely randomized design with 4 treatments, 5 plants per treatment.

Expt. 4: Bract removal and leaf shading. Plants were grown initially in a greenhouse under SD at 16°C NT for 5 weeks. Groups of plants were treated after 5, 6, or 8 weeks of SD by removing bracts, shading leaves with 75% saran, removing bracts and shading leaves, or leaving the plant untreated (control). Bracts were removed with a razor blade leaving no petiole. The 4 treatments were arranged in a completely randomized design, 5 plants per treatment. All plants remained at the same temperature.

Expt. 5: Bract and leaf removal. Plants were grown initially in a greenhouse under SD at 18°C NT. After 5, 6, 7, or 8 weeks of SD, half of the plants were moved to a 21° greenhouse, and plants at both NT were treated by removing bracts, leaves, bract and leaves, or no tissue (control). Treatments were performed all 4 dates at both temperatures. Bracts and leaves were removed using a razor blade, leaving no petiole. Data were analyzed as a completely randomized split, split plot, with temperature as the main plot, removal treatment and removal times as subplot factors, giving 32 treatments (2 temperatures × 4 removal treatments × 4 removal times), 5 plants per treatment.

Expt. 6: Plant spacing. Six weeks after the start of SD, plants were moved either to a 21°C NT greenhouse or left at 16° NT and were spaced at 11, 33, or 65 plants m^{-2}. Photosynthetically active radiation transmission was measured in the plant canopy at 10, 15, 20, and 25 cm above the bench 1, 2, and 3 weeks after spacing using a LI-COR LI-185B meter and LI190S quantum sensor (LI-COR Instrument Co., Lincoln, Neb.). Transmission was expressed as a percentage of irradiance above the canopy. For each date, 3 measurements were made at each height and spacing.

The abscission data were analyzed as a split plot design with temperature as the main plot and spacing as the subplot, giving 6 treatments (2 NT × 3 spacings), 4 plants per treatment. The mean percentage of PAR transmission at each spacing was determined by averaging all measurements over the 3 measurements dates.

Expt. 7: Nonsoluble carbohydrate determination. Six weeks after the start of SD, plants were placed under ND or SHD at

Table 2. Analysis of variance 55 to 80 days after the start of short days (SD) for poinsettia 'Annette Hegg Dark Red' grown at 16° or 18°C night temperature (NT) under normal daylight from 0 to 6 weeks after the start of short days. Plants were then moved to a 13°, 16°, 18°, or 21° NT greenhouse and/or placed under 75% shade. Half of the plants at each temperature and irradiance treatment were water stressed to −0.6 MPa. Expt. 1.

Source of variation	Days after the start of short days					
	55	60	65	70	75	80
Initial temperature (IT)	****[z]	****	****	****	****	****
Final temperature (FT)	****	****	****	****	****	****
Irradiance (I)	****	****	****	****	****	****
Water stress (ws)	***	NS	*	**	**	**
IT × FT	**	NS	NS	NS	NS	NS
IT × I	**	****	NS	NS	NS	NS
FT × I	****	****	****	****	****	****
IT × WS	*	NS	NS	NS	NS	NS
FT × WS	****	NS	NS	NS	NS	NS
I × WS	**	NS	*	***	****	****
IT × FT × I	NS	NS	NS	NS	NS	NS
IT × FT × WS	*	NS	NS	NS	NS	NS
IT × I × WS	NS	NS	NS	NS	NS	NS
FT × I × WS	*	NS	NS	NS	NS	NS
IT × FT × I × WS	NS	NS	NS	NS	NS	NS

[z]Nonsignificant (NS) or significant at 5% (*), 1% (**), 0.1% (***), or <0.1% (****).

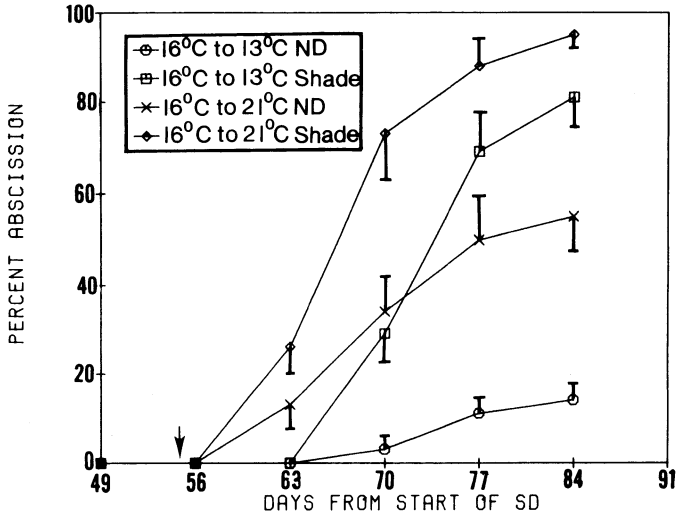

Fig. 2. Mean percentage of cyathia abscission 49 to 84 days after the start of short days (SD) for poinsettia 'Annette Hegg Dark Red' grown at an initial night temperature (NT) of 16°C under normal daylight (ND) from 0 to 6 weeks after the start of SD. Plants then were moved to a finishing NT of 13° or 21° under ND or 75% shade (Shade) from 6 weeks of SD until anthesis. Average day of anthesis was 54 to 55 days after the start of SD for all treatments, indicated by →. Vertical bars represent 1 SE. Expt. 1.

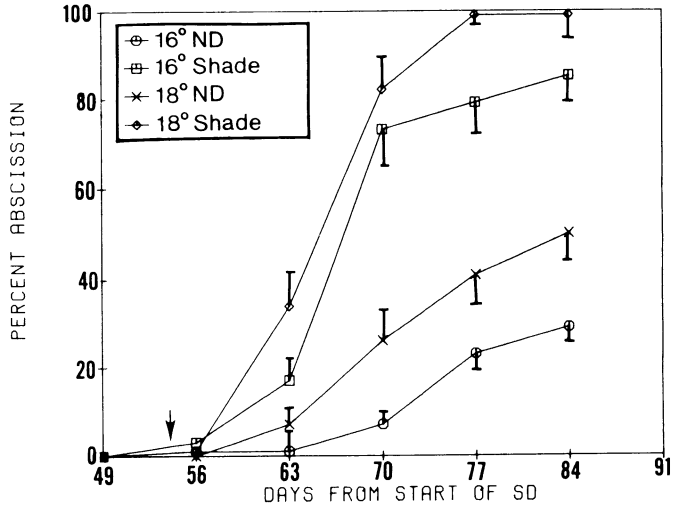

Fig. 3. Mean percentage of cyathia abscission 49 to 84 days after the start of short days (SD) for poinsettia 'Annette Hegg Dark Red' grown at a constant 16° or 18°C night temperature under normal daylight or moved to 75% shade (Shade) after 6 weeks of SD. Average day of anthesis was 54 to 55 days after the start of SD for all treatments, indicated by →. Vertical bars represent 1 SE. Expt. 1.

16° or 21°C NT. Plants were treated by removing bracts, leaves, or no tissue. There were 12 treatments, 4 plants per treatment.

Six weeks after the start of SD and every week for the following 3 weeks at 0800 HR, three 18.8 mm^2 leaf disks were removed from the first 3 leaves below the lowest bract and 3 bract disks were removed from the first fully expanded bract in each control plant. Likewise, 3 leaf disks were taken from the first 3 fully expanded bracts on each plant with leaves removed. For each plant, the same 3 leaves and bracts were sampled each week. The 3 bract or leaf disks were boiled in 95% ethanol. The tissue then was ground and diluted with 100 ml distilled water (leaf disks) or 20 ml water (bract disks). A 2 ml aliquot was pipeted out into an 18 × 150 mm test tube. Four ml of anthrone reagent (2 g anthrone dissolved in 1 liter of 100% sulfuric acid) was added to each 2 ml aliquot. The 2 solutions were mixed thoroughly and the test tubes were placed in a boiling water bath for 3 min. A marble was placed on top of each tube to prevent loss of water. The tubes were allowed to cool and the absorbance of the sample was read at 620 nm using a Beckman Model 25 spectrophotometer (Beckman Instrument Co., Fullerton, Calif.). The absorbance of each sample was compared to the absorbance of standard glucose solutions of 15, 30, 60, and 120 $\mu g\ l^{-1}$ of glucose.

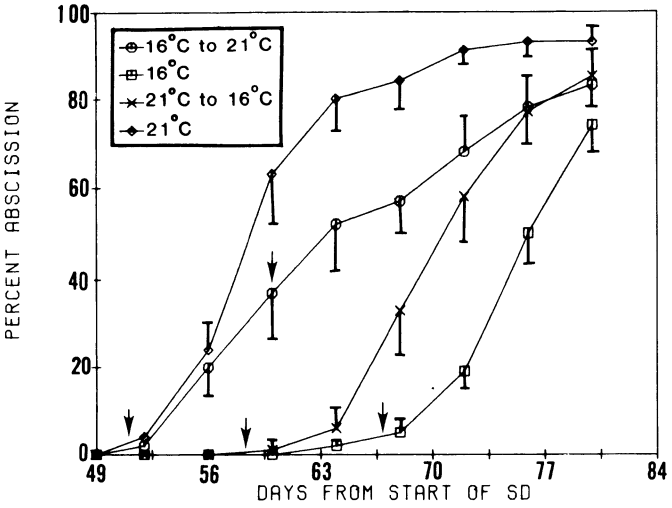

Fig. 4. Mean percentage of cyathia abscission 49 to 80 days after the start of short days (SD) for poinsettia 'Annette Hegg Dark Red' grown in a controlled environment chamber (125 μmol s^{-1} m^{-2} photosynthetically active radiation from 0800 hr to 1600 hr) at 16° or 21°C night temperature or moved after 5 weeks of SD from the 16° or 21° NT chamber to the 21° or 16° chamber, respectively. Average day of anthesis for each treatment indicated by →. Vertical bars represent 1SE. Expt. 2.

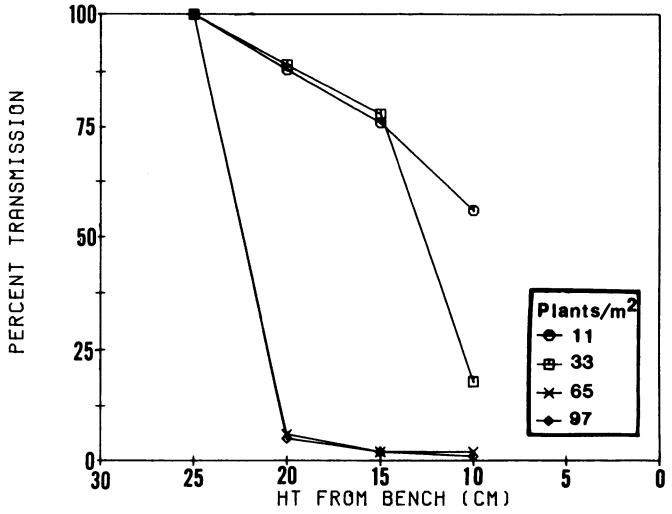

Fig. 5. Percentage of photosynthetically active radiation transmission into poinsettia 'Annette Hegg Dark Red' canopies at plant spacings of 11, 33, 65, and 97 plants m^{-2}. Expt. 6.

Analysis of variance with orthogonal contrasts was conducted to compare treatment means.

Data collection. The date of anthesis and the number of abscised cyathia were recorded on all plants daily for 25 days past anthesis (Expt. 1–5) or every 2 days for 16 days (Expt. 6). The total number of cyathia per plant was determined at the end of all experiments by counting the number of cyathia greater than 1 mm in diameter still present, plus the number of stubs remaining from previously abscised cyathia. The percentage of abscission per plant was calculated by dividing the number of abscised cyathia by the total number of cyathia formed. Statistical significance was determined by analysis of variance on arcsin transformed data.

Results

Expt. 1. Cyathia abscission was promoted by increasing the initial greenhouse temperature from 16° to 18°C, by increasing final temperature from 13° to 21°, by reducing irradiance, and by water stressing the plants (Fig. 1, Table 2). Plants grown at 16° initial temperature had less abscission than plants grown at 18° initial temperature, irrespective of finishing temperature (Fig. 1). Further, as the finishing temperature increasing from 13° to 21°, abscission increased regardless of the initial temperature. There was no interaction between the initial and final temperature except at 55 days after the start of SD (Table 2).

Plants under shade had greater abscission than plants under ND in all treatments (Fig. 1). Irradiance and finishing temperature interacted, which increased abscission under shade as finishing temperature increased (Fig. 2). Moving plants from 16° to 21°C NT (Fig. 2) did not increase abscission as much as moving plants from ND to shade while keeping NT constant at 16° (Fig. 3). There was no interaction among initial temperature, final temperature, and irradiance.

Water stress increased cyathia abscission on plants grown at an 18°C initial NT and ND (Fig. 1c), but had little effect on abscission in plants grown at 16° initial NT under ND or 75% shade, or at 18° NT and 75% shade (Fig. 1 a–c).

Expt. 2. Cyathia abscission was greater on plants grown at a constant 21°C NT compared to a constant 16° NT (Fig. 4). One week after anthesis 62% of the cyathia had abscised at a constant 21° (day 59), compared to only 20% abscission at a constant 16° (day 72). Plants moved from 16° to 21° after 5 weeks of SD had greater abscission than if moved from 21° to 16° at the same time. Plants moved from 16° to 21° also had abscised 38% of the cyathia before anthesis compared to 3% on plants grown at a constant 21°. However, abscission eventually was greater on plants grown at a constant 21°.

Expt. 3. Covering the inflorescence with aluminum foil at 5, 6, or 8 weeks of SD resulted in nonsignificant increases in cyathia abscission compared to the control (data not presented).

Expt. 4. Removing bracts from plants decreased and delayed cyathia abscission compared to nontreated plants, while shading of leaves promoted abscission (Table 3). Combined bract removal and leaf shading further hastened and increased abscission. The earlier in the SD period bracts and leaves were removed or the earlier leaves were shaded, the earlier abscission occurred and the greater the total abscission.

Expt. 5. Removing leaves greatly promoted cyathia abscission, whereas bract removal delayed abscission (Table 4). Removing bracts and leaves gave an intermediate effect. Removing leaves caused complete abscission on some plants as early as 1 week after anthesis, and the earlier leaves were removed, the earlier abscission occurred. Only 20% of the plants reached anthesis prior to cyathia abscission when leaves were removed after 5 or 6 weeks of SD, compared to 100% of the plants reaching anthesis for all other treatments (Table 4). Removing bracts significantly delayed abscission compared to the nontreated control plants. Similar results were observed at 21°C (data not presented).

Expt. 6. Spacing plants at 11 or 33 plants m^{-2} resulted in less abscission than spacing plants at 65 or more plants m^{-2} (Table 5). Plants spaced in a 21°C NT greenhouse had greater abscission than at a 16° NT.

Photosynthetically active radiation transmission into the plant canopy for spacings of 11 to 97 plants m^{-2} is shown in Fig. 5. The greatest PAR transmission occurred among plants spaced at 11 plants m^{-2}. A similar transmission curve was found through

Table 3. Mean percentage of cyathia abscission and analysis of variance 55 to 85 days after the start of short days for poinsettia 'Annette Hegg Dark Red' withy bracts removed, leaves shaded, or bracts removed and leaves shaded at 5, 6, or 8 weeks after the start of short day. Expt. 3.

Days after the start of short days[z]	Control	Weeks after the start of short days: Bracts removed 5	Bracts removed 6	Bracts removed 8	Leaves shaded 5	Leaves shaded 6	Leaves shaded 8	Bracts removed leaves shaded 5	Bracts removed leaves shaded 6	Bracts removed leaves shaded 8	Analysis of variance: Time	Treatment	Time × treatment
						Cyathia abscission (%)							
55	0	0	0	0	2	0	0	0	0	0	NS[y]	NS	NS
60	0	0	0	0	4	0	0	0	0	0	*	NS	NS
65	0	1	0	0	7	3	0	14	4	0	*	*	NS
70	0	1	0	0	7	9	0	28	11	5	*	**	NS
75	4	1	0	3	10	16	1	37	31	11	NS	**	NS
80	10	1	1	7	16	22	6	43	39	29	NS	**	NS
85	12	1	1	7	18	27	10	44	39	29	NS	**	NS

[z]Average days to anthesis at a constant 16°C was 56.
[y]Nonsignificant (NS) or significant at 5% (*), or 0.1% (**).

Table 4. Percentage of the plants reaching anthesis, mean percentage of cyathia abscission, and analysis of variance 50 to 85 days after the start of short days (SD) for poinsettia 'Annette Hegg Dark Red' grown at 18°C night temperature with bracts, leaves, or bracts and leaves removed at 5, 6, 7, or 8 weeks after the start of short days (SD). Expt. 4.

Days after start of SD[z]	Control	Weeks after the start of short days: Bracts removed 5	Bracts removed 6	Bracts removed 7	Bracts removed 8	Leaves removed 5	Leaves removed 6	Leaves removed 7	Leaves removed 8	Bracts and leaves removed 5	Bracts and leaves removed 6	Bracts and leaves removed 7	Bracts and leaves removed 8	Analysis of variance: Time	Temp	Trt	Time × temp	Time × trt	Temp × trt	Time × trt × temp
50	0	0	0	0	0	0	0	0	0	0	0	0	0	---	---	---	---	---	---	---
55	0	0	0	0	0	35	7	0	0	1	0	0	0	***[y]	NS	***	NS	****	NS	NS
60	0	0	0	2	0	83	44	1	0	13	2	0	0	****	NS	****	NS	****	NS	***
65	2	2	0	2	0	100	87	41	0	35	2	4	8	****	NS	****	NS	****	NS	NS
70	10	7	1	16	3	100	93	73	39	54	16	33	43	****	NS	****	*	****	NS	*
75	30	10	2	22	15	100	98	83	79	64	44	61	57	NS	NS	****	*	****	NS	NS
80	40	23	12	31	18	100	100	89	96	77	51	81	77	NS	NS	****	*	*	NS	**
85	46	23	17	35	21	100	100	90	99	77	61	91	93	NS	NS	****	NS	NS	NS	*
% Reaching anthesis	100	100	100	100	100	20	20	100	100	100	100	100	100							

[z]Average days to anthesis at a constant 18°C was 56 days.
[y]Nonsignificant (NS) or significant at 5% (*), 1% (**), 0.1% (***), or <0.1% (****).
[x]Percentage of the plants in each treatment that reached anthesis.

Table 5. Mean percentage of abscission and analysis of variance 62 to 70 days after the start of short days for poinsettia 'Annette Hegg Dark Red' grown at 16° or 21°C night temperature and spaced at 11, 33, or 65 plants m^{-2}. Expt. 5.

Days from start of short days[z]	Plants m^{-2}: 16°C 11	16°C 33	16°C 65	21°C 11	21°C 33	21°C 65	Analysis of variance: Spacing	Temperature	Spacing × temperature
62	0	0	0	0	0	6	NS	NS	NS
64	1	1	1	0	0	8	NS	NS	NS
66	2	2	1	2	5	22	NS	NS	NS
68	4	3	9	3	6	25	***	**	**
70	6	4	15	7	11	30	***	*	**

[z]Average days to anthesis at a constant 16° and 21°C night temperature was 54 and 51 days.
[y]Nonsignificant (NS) or significant at 5% (*), 1% (**) or <0.1% (***).

the top 10 cm of the canopy for plants spaced at 33 plants m^{-2}, but, PAR transmission dropped off significantly as measurements were lower in the canopy. Spacing at 65 or 97 plants m^{-2} had almost identical PAR transmission curves, with transmission decreasing to less than 10% of the above canopy irradiance 5 cm into the canopy.

Expt. 7. Nonsoluble carbohydrates expressed as glucose equivalents increased from the 6th to the 9th week of SD in leaves of plants with bracts removed (Table 6). In contrast, carbohydrates decreased in leaves of whole plants (bracts present).

Averaged over all treatments, leaves grown under ND had significantly greater carbohydrates than if grown under shade; however, carbohydrates were similar at 16° and 21° NT.

There were significantly greater carbohydrates in bracts of plants with leaves removed than in whole plants (leaves present)

Table 6. Mean glucose equivalents per 3 leaf or bract disks sampled at 6, 8, or 9 weeks after the start of short days from bracts and leaves of poinsettia 'Annette Hegg Dark Red' grown at 16° or 21°C night temperatures under normal daylight or 75% shade. Expt. 6.

Weeks after start of short days	Mean glucose equivalents							
	16°				21°			
	Normal daylight		75% shade		Normal daylight		75% shade	
	Whole plant	Bracts/leaves[z] removed	Whole plant	Bracts/leaves removed	Whole plant	Bracts/leaves[z] removed	Whole plant	Bracts/leaves removed
				Leaves				
6	29	---	87	---	34	---	44	---
8	57	75	18	24	20	69	10	18
9	39	89	14	31	24	83	9	34
				Bracts				
6	---	---	---	---	---	---	---	---
8	29	31	22	32	17	31	12	21
9	17	25	14	21	10	22	9	8

Contrasts[y]	*Leaves*	*Bracts*
Whole plant vs. bract/leaf removal[z]	***[x]	**
Whole plant vs. bract/leaf removal (16°)	**	*
Whole plant vs. bract/leaf removal (21°)	***	NS
Normal daylight vs. 75% shade	***	*
Normal daylight vs. 75% shade (16°)	***	NS
Normal daylight vs. 75% shade (21°)	**	*
16° vs. 21°C	NS	**

[z]Bracts removed for leaf data; leaves removed for bract data.
[y]Contrasts on data at 9 weeks after the start of short days.
[x]Nonsignificant (NS) or significant at 5% (*), 1% (**) or <0.1% (***) level.

averaged over both NT (Table 6). Bract carbohydrates decreased in all treatments from 7 to 9 weeks of SD. Bracts grown under ND had greater carbohydrates than if grown under shade, and carbohydrates were higher at 16°C compared to 21° (Table 6). At 16°, there were no differences in carbohydrates under ND or shade, although carbohydrates were higher in bracts grown under ND than shade at 21°.

Discussion

Low irradiance levels and high temperatures promoted cyathia abscission; however, water stress did not increase abscission consistently. Comparing low irradiance levels and high temperatures, low irradiance appeared to be the primary factor promoting abscission on plants in the greenhouse. When plants were moved from ND to shade at 16° NT after 6 weeks of SD, 63% of the cyathia had abscised 14 days after normal anthesis, whereas only 29% of the cyathia had abscised at the same time when plants remained under ND but were moved from 16° to 21°C NT (Fig. 1). Compared to decreasing irradiance alone, increasing the finishing temperature to 21° and decreasing irradiance simultaneously only increased abscission an additional 6%, to 69%.

Decreasing the amount of available PAR reaching the plant canopy by shading or by increasing plant density (Fig. 5) increased abscission (Tables 3, 4, 5), probably by lowering the carbohydrate supply to the bracts and cyathia. Measurements of glucose equivalents confirm that shade significantly reduced nonsoluble carbohydrates in the bracts and leaves (Table 6). Removing bracts (removal of sink competition) increased carbohydrates in leaves, which could explain why there was little or no cyathia abscission (Tables 3, 4). Limiting photosynthate availability by removing leaves likewise would have limited carbohydrates available to the sinks. Reduced carbohydrate supplies have promoted the abscission of leaves, flowers, and fruit (1). Woodhead and Einert (27) reported cyathia abscised when poinsettia plants were placed in a postharvest environment under high temperatures and low irradiance levels (about 21°C under 7 μmol s^{-1} m^{-2} PAR for 16 hr d^{-1}) before the bracts were half-colored.

Temperature also influenced cyathia abscission. As the initial temperature or finishing temperature increased, cyathia abscission was promoted, especially if plants were grown under shade (Fig. 1). Under constant irradiance and temperature, cyathia abscission also increased at the higher finishing temperature (21° vs. 16°C) (Fig. 5). The increase in abscission as finishing temperature increased may have due to carbohydrate depletion. As temperature increases, respiration rates increase (12), decreasing the plant carbohydrate supply. Carbohydrate levels were lower in bracts or leaves at 21° compared to 16° (Table 6). Abscission has been reported to increase as the temperature increased in explants of beans (29), and cotton (10), and in petal abscission in *Linum lewisii* (25). Flower buds, flowers, and young pods of snap bean also are known to abscise in response to high temperatures (26).

Plants water stressed at an 18°C initial NT under ND (Fig. 1c) had greater abscission than plants growing under shade (Figs. 1b, 1d). Under shade, significant abscission already had occurred due to the low irradiance level at the time a water stress occurred, so there were few additional cyathia to abscise. Also, many cyathia were still present on plants growing under ND, so water stress had the potential for causing more abscission.

Sink size and strength may have influenced abscission. We hypothesize that carbohydrates translocated from source leaves are partitioned to the bracts and cyathia (sinks). The bracts appeared to be stronger sinks than cyathia, because when leaves were removed, the bracts remained intact while the cyathia abscised (Table 4). Removing the bracts had an opposite effect in that little or no cyathia abscission occurred, and the cyathia became larger than normal (data not presented) and developed far past anthesis (Tables 3, 4). The removal of bracts probably

allowed increased translocation of carbohydrate to the cyathia, which accounted for the large size and absence of abscission. Therefore, abscission may be due to the cyathia's failure to mobilize sufficient carbohydrates to complete development when bracts are present, especially when carbohydrates are limiting. Decreased carbohydrate translocation as a result of low irradiance has caused fruit abscission (16) and improper flower bud development in rose (11), tomato (8), iris (9), and *Bougainvillea* (23).

It has been hypothesized that adequate carbohydrates are necessary for continued synthesis of abscission-inhibiting hormones in actively growing roots and shoots (6, 13, 15). If carbohydrate levels are low, hormone production may decrease in roots and shoots, and the organ abscises. Alternatively, it has been suggested that translocation of carbohydrates to an organ (sink) is directed by the hormone level in the organ (1, 14, 19). If the level of auxin, gibberellin, or cytokinin is low due to some environmental stress (low irradiance level, high temperatures, or water stress) the attraction of carbohydrates by the organ decreases and the organ abscises (1). With regard to cyathia abscission in poinsettia, neither hypothesis can be supported directly by this research.

These results suggest that premature cyathia abscission on poinsettia plants in greenhouses is caused primarily by low irradiance levels. High greenhouse temperatures alone will increase abscission to a limited degree. Waterstress may also promote abscission, depending on irradiance and temperature. Abscission usually is intensified when high greenhouse temperatures are combined with low irradiance levels. Natural irradiance levels in greenhouses decline in the fall. Irradiance levels to the leaves are reduced further as bracts expand or as plant density increases. Greenhouse temperatures may be elevated to hasten crop development. Low irradiance levels and/or high temperatures may cause carbohydrate decline, resulting in cyathia abscission.

Preventative measures appear to be the only means of controlling the problem of premature cyathia abscission in poinsettia. Early flower initiation in late September will allow the cyathia to develop under higher irradiance levels.Proper night temperature control in October and early November (4) will allow lower finishing temperatures to be used. Spacing plants as they are marketed will allow for greater irradiance penetration to the leaves, increasing carbohydrates available to the cyathia.

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