Table 2. The effects of seeding rate on light transmission through the canopy within and between the rows of the transplanted meadow.

Date (1993)	Week	Light transmission (µmol·s^{-1}·m^{-2}) Within: Seeding rate (1 g·90m^{-2}) 56	112	Between: Seeding rate (g·m^{-2}) 56	112
25 June	2	5489 a	5522 a	5250 a	5331 a
9 July	4	3483 a	2345 b	1828 a	1013 a
23 July	6	748 a	450 a	279 a	292 a
9 Aug.	8	253 a	262 a	202 a	193 a
20 Aug.	10	275 a	264 a	167 a	160 a
3 Sept.	12	346 a	211 a	169 a	96 b

[z]Mean separation within rows (date), Student–Newman–Keuls test, $P = 0.05$.

Table 3. The effects of weed control method on light transmission through the canopy within and between the rows of the transplanted meadow.

		Light transmission (µmol·s^{-1}·m^{-2})					
Date		Within			Between		
(1993)	Week	Control	Mulch	Oryzalin	Control	Mulch	Oryzalin
25 June	2	5517 a[z]	5450 a	5550 a	5354 a	5279 a	5238 a
9 July	4	2044 b	3117 a	3581 a	863 b	1007 b	2392 a
23 July	6	348 b	719 a	729 a	153 b	143 b	561 a
9 Aug.	8	199 c	256 b	318 a	161 b	182 b	250 a
20 Aug.	10	220 b	233 b	355 a	130 b	131 b	231 a
3 Sept.	12	176 b	298 a	361 a	124 a	126 a	148 a

[z]Mean separation within rows (date), Student–Newman–Keuls test, $P = 0.05$.

transmission levels to that in the control plots. This is likely a result of less weed competition and greater moisture availability provided by the mulch cover. Oryzalin-treated plots allowed the highest light transmission levels through week 12 compared to the mulch and control plots. These plots appeared to have fewer plants, likely resulting from a phytotoxic response to the herbicide or due to the prevention of further seed germination immediately following transplanting. In the mature meadow, the mulched and control plots appeared to have more *Celosia*, *Tagetes*, and *Zinnia* than the oryzalin-treated plots. *Coreopsis tinctoria* appeared to be the predominant species in the oryzalin-treated plots.

Stand density was manipulated by planting fewer seeds and transplanting the plugs further apart. Both of these methods are viable options for using less seed and reducing the overall cost of the technique. The one negative effect was the lack of interplant support in the mature meadow. The preemergent herbicide, oryzalin, provided excellent weed control at a the expense of some species diversity and speed of establishment. Mulch, while labor intensive to apply, provided excellent weed control with the added benefit of enhancing plant growth.

Literature cited

Bartels, E. 1992. Restoring the northeastern meadow. Landscape Architecture December:74–77.

Derr, J.F. 1993. Wildflower tolerance to Metolachlor and Metolachlor combined with other broadleaf herbicides. HortScience 28:1023–1026.

Derr, J.F. and B.L. Appleton. 1992. Combinations of fabrics and films with organic and inorganic mulches for landscape weed control. Proc. Southern Nurserymen's Assn. Res. Conf. 37:291–293.

Martin, L.C. 1986. The wildflower meadow book. Fast and McMillan Publishers, Charlotte, N.C.

Wilson, J. 1992. Landscaping with wildflowers. Houghton Mifflin Co., Boston.

Photoperiod of Poinsettia Stock Plants Influences Rooting of Cuttings

Michael J. Roll and Steven E. Newman[1]

Additional index words. flower initiation, propagation

Summary. **Rooting of cuttings from three cultivars of *Euphorbia pulcherrima* Willd. was evaluated after regulating the photoperiod during the stock plant stage. One group of stock plants was exposed to a night break (4 hours) and another group was exposed to natural daylength during September. Cuttings harvested in late September from 'Freedom Red' and 'Monet' stock plants grown under the 4-hour night break rooted more rapidly and had greater root mass than 'Freedom Red' and 'Monet' grown under natural daylength, whereas rooting of cuttings from 'V-17 Angelika Marble' was not influenced by the photoperiods tested. Using a night break to prevent flower initiation of stock plants produced a higher-quality cutting when propagation took place after the critical daylength for flowering had passed.**

Vegetatively propagated cuttings from stock plants produce flowering plants true to cultivar (Ecke et al., 1990). The speed of adventitious rooting from vegetatively propagated cuttings is important because rapid rooting minimizes exposure to diseases, which is a major

Department of Horticulture and Landscape Architecture, Colorado State University, Fort Collins, CO 80523-1173.

Funding was provided by the Colorado Agricultural Expt. Station (project 642). We appreciate Colorstar Greenhouse, Ft. Lupton, Colo., for providing plant material for this study.

[1]Graduate student.

[2]Extension specialist in greenhouse crops.

The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

Table 1. Percentage of total cuttings with visible roots from *Euphorbia pulcherrima* 'Freedom Red', 'Monet', and 'V-17 Angelika Marble' stock plants exposed to a 4-h night break and natural photoperiod. Cuttings were harvested 29 Sept. 1995.

Cultivar	Photoperiod	Percentage of total cuttings rooted (days after stick) 14	18	21	26	31
Freedom Red	Natural	30 b[z]	62 b	78 b	90 a	100 a
	Night break	44 a	88 a	100 a	100 a	100 a
Monet	Natural	6 a	20 b	40 b	46 b	78 a
	Night break	10 a	36 a	64 a	86 a	96 a
V-17 Angelika Marble	Natural	38 a	72 a	86 a	96 a	100 a
	Night break	28 a	70 a	92 a	94 a	100 a

[z]Means within columns followed by different letters are different at $P < 0.05$ as determined by a pairwise t test. Means based on 10 cuttings.

Table 2. Dry mass of roots excised from cuttings from *Euphorbia pulcherrima* 'Freedom Red', 'Monet', and 'V-17 Angelika Marble' stock plants exposed to a 4-h night break and natural photoperiods.

	Poinsettia cultivars Root dry mass (mg)		
Photoperiod	Freedom Red	Monet	V-17 Angelika Marble
Natural	17.6 b[z]	0.3 b	28.9 a
Night break	52.4 a	7.9 a	27.3 a

[z]Means within columns followed by different letters are different at $P < 0.05$ as determined by a pairwise t test. Data were analyzed and mean separations were conducted as a $\log_{10}$ transformation but are presented as nontransformed data. Means based on 15 cuttings.

concern with unrooted cuttings. Cuttings must root quickly and sufficiently to develop a high-quality plant in as short a period of time as possible. Growers have exposed stock plants to various daylength treatments to increase rooting of cuttings for many years. Biran and Halevy (1973) reported that daylength had an indirect effect on rooting through its effect on the production of flower buds for dahlia cuttings. Their results showed that vegetative cuttings rooted better than reproductive cuttings.

There is a growing market for miniature poinsettias, which are small single-stemmed plants, for baskets or novelty sales. They typically are rooted directly in their finished pot size after 15 Sept. in the middle latitudes of the United States (J. Hall, personal communication). Our study determined that late-season rooting of poinsettia cuttings was affected by stock plant photoperiod.

Materials and methods

Poinsettia stock plants were received 14 Aug. 1995 from a local greenhouse grower. Three cultivars were used including 'Freedom Red', 'Monet', and 'V-17 Angelika Marble'. From 1 Sept. through 29 Sept. 1995, five stock plants from each cultivar were exposed to a 4-h night break from 30-W incandescent bulbs spaced 1.2 m on center between 10:00 PM and 2:00 AM MST in a fiberglass-covered greenhouse. An additional five stock plants from each cultivar were grown under natural daylength conditions during this same period in a separate fiberglass-covered greenhouse. The day temperature in both greenhouses was 24 ± 2 °C, and the night temperature was 19 ± 2 °C, which changed in response to photoperiod. All stock plants were drenched 22 Sept. 1995 with metalaxyl and thiophanate-methyl and were treated with imidacloprid 21 Aug. 1995 at the labeled rates. On 29 Sept. 1995, 10 five-node cuttings from each stock plant were harvested. From each group of 10 cuttings, five cuttings where dipped in a talc formulation of 0.1% indole-3-butyric acid (IBA, Hormodin 1, Merck & Co., Rathway, N.J.). This procedure resulted in four combinations that were observed for root initiation, including night break with hormone, no night break with hormone, night break without hormone, and no night break without hormone.

Cuttings were randomized in flats of perlite, spaced 8 × 6 cm, and placed under intermittent mist. Mist cycles used were 32 s every 8 min. Perlite was used as the rooting substrate to allow for repeated observations of rooting. After 7 d, misting was reduced to 8 s every 16 min, and after an additional 14 d, the mist bench was adjusted to 4 s every 32 min for the duration of the study. Ambient temperatures in the propagation house were maintained at 25 ± 2 °C during the day and 20 ± 2 °C at night under natural daylength. All cuttings were inspected for root emergence and were replanted 14, 18, 21, 26, and 31 d after placing under mist. Root emergence was recorded when the first root meristem was visible. Roots were excised after 34 d using random groups of 15 cuttings representing all four treatments and every cultivar (180 cuttings). Roots from each cutting were oven-dried and weighed individually.

The study was conducted as a 2 × 2 × 3 factorial design with repeated measures including two levels of IBA (with or without), two photoperiod levels (natural or night break), and three cultivars ('Freedom Red', 'Monet', and 'V-17 Angelika Marble'), with five cuttings per treatment combination. Analyses were conducted by general linear model and least-squared means on nontransformed data for rooting percentages as the variances were normal. Root dry mass data were analyzed as $\log_{10}$ transformations to account for the magnitude of differences between the three cultivars but are presented as nontransformed data.

Results and discussion

Applying IBA was not effective in increasing rooting or the speed of rooting on any of the poinsettia cultivars under either light regimen (data not shown). Therefore, IBA effects were pooled in the data analysis. Stock plant photoperiod, however, did influence the rooting of poinsettia cuttings. 'Freedom Red' and 'Monet' cuttings rooted more quickly when the stock plants were grown with a night break (Table 1). Furthermore, the root dry mass of these cuttings were greater than the root dry mass of control 'Freedom Red' and 'Monet' cuttings (Table 2). There was no variation in rooting time and root mass among 'V-17

Angelika Marble' cuttings, regardless of the treatment of the stock plants (Tables 1 and 2).

Although the reaction to extended photoperiods of stock plants varies among species, it is widely accepted that long days during the stock plant stage is an important factor in the subsequent rooting of individual poinsettia cuttings (Hansen and Ernstsen, 1982). Poinsettias typically require short days to initiate flowering. The critical photoperiod for the initiation of flowering for most poinsettia cultivars has been established at 12 h 20 min (Ecke et al., 1990), which at 40° 35′ N latitude, occurred naturally on 19 Sept. 1995. However, to our knowledge, there has been no research performed on the critical photoperiod of modern poinsettia cultivars to verify the difference in flower initiation dates (D. Hartley, personal communication).

While the stock plants under natural lighting would have initiated flowering, it is most likely that the critical dark period for 'V-17 Angelika Marble' is longer than that for 'Freedom Red' or 'Monet', and flowering initiation had not yet occurred. Consequently, there may not have been any physiological difference between the cuttings taken from 'V-17 Angelika' stock plants grown under natural and night-break treatments. For 'Freedom Red' and 'Monet', there was a physiological difference between the cuttings, perhaps due to the flower initiation of the stock plants under a natural daylength.

In short-day and long-day plants, flower initiation within the stock plants appears to inhibit rooting of the cuttings (Heide, 1965; Moe 1976). A short-day species, *Dendranthema* spp., produced superior cuttings using long-day treatments on the stock plants to block the initiation of flowering (Heins et al., 1980). Similar stock plant photoperiodic effects have been reported on *Salix* spp., *Abelia* ×*grandiflora, Kalanchoe tubiflora, Crassula argentea, Ilex crenata, Pinus sylvestris* using short days to increase rooting, whereas *Begonia* ×*cheimantha, Vigna radiata,* and *Rhododendron spp.* exhibited increased rooting under long days (Hansen, 1987).

Many studies have produced evidence showing that herbaceous stock plants in a vegetative stage produce cuttings that root quickly and yield more root mass. More systematic research is required to identify the critical photoperiod of individual poinsettia cultivars. Identifying the critical daylength of a specific cultivar for flowering is important when deciding whether lighting the stock plant is a necessary treatment for photoperiodic control. If the critical day length occurred before cuttings were harvested or rooting occurs, it would be necessary to extend the photoperiod to inhibit flower initiation, thereby producing a cutting capable of rooting. However, lighting would be unnecessary if rooting occurred before the critical daylength was reached and flower initiation had not yet occurred.

Literature cited

Biran, I. and A.H. Halevy. 1973. The relationship between rooting of *Dahlia* cuttings and the presence and type of bud. Physiol. Plant. 28:244–247.

Ecke, P., Jr., O.A. Matkin, and D.E. Hartley. 1990. The poinsettia manual, 3rd. ed. Paul Ecke Poinsettia Ranch, Encinitas, Calif.

Hansen, J. 1987. Stock plant lighting and adventitious root formation. HortScience 22:746–749.

Hansen, J. and A. Ernstsen. 1982. Seasonal changes in adventitious root formation in hypocotyl cuttings of *Pinus sylvestris*: Influence of photoperiod during stock plant growth and of indolebutyric acid treatment of cuttings. Physiol. Plant. 17:789–804.

Heide, O.M. 1965. Effects of light and temperature on the regeneration ability of *Begonia* leaf cuttings. Physiol. Plant. 17:789–804.

Heins, R., W.E. Healy, and H.F. Wilkins. 1980. Influence of night lighting with red, far-red, and incandescent light of *Chrysanthemum* cuttings. HortScience 15:84–85.

Moe, R. 1976. Environmental effects of stock plants on rooting and further growth of the cuttings of *Campanula isophylla* Moretti. Acta Hort. 64:71–81.

Influence of Freeze Acclimation Procedure on Survival and Regrowth of Container-grown *Campanula takesimana* Nakai.

Todd A. Herrick[1] and Leonard P. Perry[2]

ADDITIONAL INDEX WORDS. bellflower, *Campanulaceae*, cold acclimation, cold hardiness, overwintering, perennials

SUMMARY. Crown divisions of *Campanula takesimana* were potted 1 Sept. 1994 and were grown under natural conditions until 19 Nov., when they were moved into a 3 °C greenhouse. On 15 Feb. 1995, 10 plants were randomly assigned to each of four temperature treatments (–5, –8, –11, and –14 °C), using each of four freeze acclimation procedures designated A through D: group A plants were held at treatment temperatures for 30 minutes; group B plants were first subjected to three alternating freeze–thaw cycles (–3 °C for 24 hours, 3 °C for 24 hours), then held at treatment temperatures for 30 min; plants in group C were held at –1 °C for 14 days and subsequently were exposed to treatment temperatures for 30 minutes; group D plants

This research was supported in part by funds provided through Hatch Project VT-503, the Vermont Association of Professional Horticulturists, and New England Grows. Use of trade names implies neither product endorsement nor criticism of similar products.

[1]Former graduate research assistant, Dept. of Plant and Soil Science, Univ. of Vermont, Burlington, VT 05401; current address, Minnesota Landscape Arboretum, 3675 Arboretum Blvd., Chanhassen, MN 55317.

[2]Extension associate professor, Dept. of Plant and Soil Science, University of Vermont, Burlington, VT 05405.

The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.