HRI's Mission:

To direct, fund, promote and communicate horticultural research, which increases the quality and value of ornamental plants, improves the productivity and profitability of the nursery and landscape industry, and protects and enhances the environment.

The use of any trade name in this article does not imply an endorsement of the equipment, product or process named, nor any criticism of any similar products that are not mentioned.

Shasta Daisy Cultivars Respond Differently to Photoperiod and Vernalization[1]

J.T. Coleman[2], J.R. Kessler, Jr.[3], G.J. Keever[5], and J.L. Sibley[4]
Department of Horticulture
Auburn University, AL 36849

Abstract

Inconsistencies have been reported in the role of vernalization and photoperiod on growth and flowering of *Leucanthemum* x*superbum* Bergmans ex J. Ingram cultivars. Five cultivars were used to determine the effects of vernalization and photoperiod on days to flower, shoot height, growth index, flower shoot number, and quality rating. Plants received 0, 3, 6, 9, or 12 weeks of vernalization time (VER) at 4.4C (40F) and afterward were placed under either natural short days (SD) or night-interrupted lighting (NIL) in a greenhouse. 'Becky' showed an obligate requirement for NIL to flower with 100% of plants flowering under NIL and 0% of plants flowering under SD regardless of VER. Vernalization for 6 weeks before NIL increased shoot height, growth index, flower shoot number, and quality rating but the fewest days to flower occurred after 12 weeks of VER. 'Silver Princess', 'Snow Cap', 'Snow Lady', and 'Summer Snowball' showed a facultative requirement for NIL to flower. Plants under NIL flowered earlier, were larger, had more flower shoots, and had a higher overall quality rating than plants under SD. Shoot height and growth index were highest under NIL after 3 and 6 weeks of VER, flower shoot number was highest after 3 to 9 weeks of VER, but days to flower was least after 12 weeks of VER. Therefore, NIL after 3 or 6 weeks of VER would maximize plant size and quality for practical application in the cultivars studied but result in more DTF when compared to 12 weeks of VER.

Index words: flowering, chilling, day length, production.

Species used in this study: 'Becky', 'Silver Princess', 'Snow Cap', 'Snow Lady', 'Summer Snowball' Shasta daisy (*Leucanthemum* x*superbum*).

Significance to the Nursery Industry

Sales of flowering plants generally improve if plants are sold while in bloom and are vigorous and uniform in growth. Knowing whether vernalization, long days or a combination of the two improve uniformity, vigor and flowering of herbaceous perennials for the spring marketing season may improve opportunities for sales. In this study, Shasta daisy 'Becky' showed an obligate requirement for long days to flower. 'Silver Princess', 'Snow Cap', 'Snow Lady' and 'Summer Snowball' showed a facultative response for long days to flower, but in practical application, should be treated as obligate long-day plants. Growth factors including, shoot height, growth index, quality rating, flower shoot number were improved by 3 and 6 weeks of vernalization at 4.4C (40F) followed by night-interrupted lighting during natural short days.

Introduction

Flowering herbaceous plants are a growing segment of the U.S. flower market. Wholesale value of herbaceous perennials was $708 million in 2005 (5). Sales of flowering plants generally improved if plants were sold while in bloom and were vigorous and uniform in growth (1). Herbaceous perennials can be forced into flower under greenhouse conditions by manipulating vernalization and photoperiod (2).

Differences have been reported concerning the role of photoperiod and vernalization (VER) in flowering of Shasta daisy (*Leucanthemum* x*superbum*). Shasta daisy was reported to be a long day plant because flowering was hastened by simulated long days with 4 h night-interrupted lighting (7) or day length extension from 6:00 to 10:00 pm (8). 'Esther Read' and 'T.E. Killian' required long days to flower, but the day length required varied with the cultivar, 13 and 15 hours, respectively (6). When 'G. Marconi' seedlings were transferred from short days to longs days with an increasing number of leaves, flowering did not occur under continuous short days and only sparsely under long days (3). Shedron and Weiler (12) reported that 'G. Marconi' seedlings did not flower under short days and flowered only 10–20% under long days with no VER. Seedlings given 0 to 16 weeks of VER at 4 week intervals followed by short days flowered 100% only after receiving 16 weeks of VER. Seedlings of different genotypes given combinations of different VER intervals followed by short or long days varied in flowering response. The authors concluded that the description of Shasta daisy as a long day plant was imprecise because some genotypes responded qualitatively and others quantitatively to VER and photoperiod.

Cameron et al. (2) reported that long days were horticulturally required for flowering of 'Snow Lady'. Non-vernalized 'Snow Lady' seedlings transferred from short days to long days with an increasing number of leaves flowered fastest from the cotyledon stage and progressively slower with up to 24 leaves (3). These authors found a facultative long day response in 'Snow Lady' and showed that floral initiation is faster and more uniform under long days than short days with no prior VER. When 'Snow Lady' seedlings were given no VER or 4 months outdoor VER followed by either short days, continuous long days, or a range of long days from 6 to 22 at 2 day increments followed by short days, non-vernalized seedlings flowered faster than those that received VER indicating a lack of VER requirement in this cultivar (4).

[1]Received for publication February 17, 2006; in revised form March 15, 2007.

[2]Graduate Student. <colemjt@auburn.edu>

[3]Associate Professor. <kessljr@auburn.edu>

[4]Associate Professor. <sibleje@auburn.edu>

[5]Professor. <keevegj@auburn.edu>

'Snow Cap' given no VER or 15 weeks VER followed by either day lengths ranging from 10 to 16 h at 2 h increments, continuous light, or a 9 h photoperiod with night-interrupted lighting did not flower without VER and photoperiods ≤ 14 h (9). Plants that received VER flowered regardless of photoperiod. In a second study, plants received 0 to 15 weeks of VER at 3 week intervals followed by a 9 h photoperiod with or without night-interrupted lighting. With a 9 h photoperiod, percent flowering increased and flowering time decreased with increasing VER time. Plants given night-interrupted lighting and that received ≥ 3 weeks of VER flowered fastest. The authors recommended VER for 6 weeks followed by at least a 16 h photoperiod for forcing 'Snow Cap'. The objective of this study was to determine the role of photoperiod and VER duration on growth and flowering of five *Leucanthemum* x*superbum* cultivars.

Materials and Methods

On October 10, 1997, plugs of *Leucanthemum* x*superbum* 'Becky', 'Silver Princess', 'Snow Cap', 'Snow Lady' and 'Summer Snowball' in 72-cell flats (Yoder Greenleaf Enterprises, Inc., Leola, PA) were transplanted to 15-cm (6 in) azalea pots containing Fafard #3 growing medium (Fafard, Anderson, SC). Plants were grown in an unshaded glass-covered greenhouse with a heating set point of 18.3C (65F) and a ventilation set point of 25.6C (78F). Plants were fertilized weekly with 150 ppm N using 20N–4.4P–16.6K (Pro Sol 20–10–20, Frit Industries, Inc., Ozark, AL) fertilizer. Plants were watered when the medium appeared dry, but before plants wilted.

On February 14, 1998, 72 plants of each cultivar were placed in a walk-in cooler set at 4.4C (40F) for 3, 6, 9, or 12 weeks of VER treatment and irrigated as needed with water. While in the cooler, plants received 9 hours of incandescent light at a minimum of 10 ft-c from 0800 hours to 1700 hours.

Eighteen control plants of each cultivar and those removed from the cooler as VER treatments were completed were held in an unshaded glass-covered greenhouse with a heating set point of 18.3C (65F) and a ventilation set point of 25.6C (78F). In the greenhouse, half of the plants from each VER treatment were placed under either natural short days (SD) or night-interrupted lighting (NIL). NIL was provided by incandescent lamps from 2200 hours to 0200 hours. Beginning March 14, 1998, plants in the natural day length treatments received black cloth from 1700 hours to 0800 hours until flower buds opened. Weekly fertilization resumed for all plants once placed in the greenhouse at the previously reported rate. Plants were spaced on 30.5 cm (1.0 ft) centers.

Data recorded were date of first open flower (ray floret petals reflexed perpendicular to the peduncle) and at the time of first flower, shoot height, growth index [GI = (height + widest width + width 90°) / 3], and number of flowering shoots. No growth data were recorded on plants without flowers. A market quality rating was recorded when five flowers were open (or when all flowers were open if the plant had less than five flowers) consisting of 1 = foliage not beyond pot rim, 1–4 flowers and buds; 2 = any one leaf up to 2.5 cm (1 in) beyond pot rim, 5–9 flowers and buds; 3 = any one leaf 5.0 cm (2 in) beyond pot rim, 10–13 flowers and buds; 4 = any one leaf 7.6 cm (3 in) beyond pot rim, 14–17 flowers and buds; 5 = any one leaf greater than 7.6 cm (3 in) beyond pot rim, greater than 17 flowers and buds. A quality rating of zero was assigned to plants that did not flower by the termination of the experiment.

Cultivars were randomized separately and analyzed as separate experiments. The experiment design was a split-plot with photoperiod as the main plot and cooler time as the subplot. Data were analyzed using the PROC GLIMMIX procedure (10) to determine significance of main effects and interactions. Responses to photoperiod were determined using the main effect F-test. Response to VER was determined using linear and quadratic orthogonal polynomials (P = 0.05) in the cases of univariate responses. Quality ratings were analyzed as ordinal responses (11). Mean separation for quality ratings were determined using t-tests, (P = 0.05) from PROC GLIMMIX.

Table 1. Percent flowering of five *Leucanthemum* x*superbum* cultivars in response to vernalization duration and short photoperiods or night-interrupted lighting.

Cultivar	Photoperiod	Vernalization (weeks) 0	3	6	9	12
'Silver Princess'	SD[z]	0[y]	90	78	78	100
	NIL	100	100	100	100	100
'Snow Cap'	SD	33	0	89	22	100
	NIL	100	100	100	100	100
'Snow Lady'	SD	0	78	78	89	100
	NIL	100	100	100	100	100
'Summer Snowball'	SD	22	0	22	11	100
	NIL	100	100	100	100	100
'Becky'	SD	0	0	0	0	0
	NIL	100	100	100	100	100

[z]SD = short day lengths, NIL = night-interrupted lighting.
[y]n = 9.

Results and Discussion

'Silver Princess' plants flowered 100% under NIL, regardless of VER, while 70% of plants receiving 3 to 12 weeks of VER under SD flowered, but none of the plants under SD flowered without VER (Table 1). The interaction between photoperiod and VER was significant for flower shoot number and quality rating (Table 2). Flower shoot number increased linearly with increasing VER under SD showing a 158% increase after 12 weeks compared to 3 weeks of VER. Flower shoot number changed quadratically with increasing VER under NIL with the highest shoot numbers occurring after 3, 6, or 9 weeks of VER, a difference of 3 and 2 shoots when compared to 0 and 12 weeks of VER, respectively. Quality ratings were not different under SD after 3 to 12 weeks of VER or under NIL after 0 to 12 weeks of VER. However, overall quality ratings under NIL were about 1.5 units greater than those under SD.

'Silver Princess' showed no interaction between photoperiod and VER for DTF, shoot height, or growth index (Table 3). Plants under NIL required 2 fewer DTF, were 7.1 cm (2.8 in) taller, and had a 7% larger growth index at first flower than those under SD. Days to flower decreased linearly with increasing VER, and plants required 18 fewer DTF after 12 weeks of VER compared to no VER (Table 3). There were no differences among VER treatments for shoot height. Growth index changed quadratically with increasing VER,

Table 2. Response of five *Leucanthemum* x*superbum* cultivars to vernalization duration and natural short photoperiod or night-interrupted lighting[z].

		Vernalization (weeks)					
	Photoperiod	0	3	6	9	12	Significance[y]
				'Silver Princess'			
Flower shoot number	SD[x]	—[w]	3b[v]	5b	6[ns]	7[ns]	L**
	NIL	5	8a	8a	8	6	Q**
Quality Rating[u]	SD	0b[t]	1.7a	1.9a	1.9a	2.3a	
	NIL	3.1[ns]*	3.1*	3.1*	3.1*	2.8*	
				'Snow Cap'			
Days to flower	SD	75a	—	61a	53a	47a	L***
	NIL	55b	52	48b	44b	38b	L***
Flower shoot number	SD	1b	—	2b	4b	6b	L***
	NIL	5a	9	11a	10a	11a	L***
Growth index[s]	SD	25.2b	—	25.4b	23.6b	24.7b	NS
	NIL	27.9a	30.8	32.0a	26.7a	27.1a	Q***
Quality rating	SD	0.3c	0c	1.1b	0.4c	2.7a	
	NIL	3.3b*	3.9a*	4.0a*	3.8a*	3.9a*	
				'Snow Lady'			
Flower shoot number	SD	—	8b	7b	8	8	NS
	NIL	8	9a	14a	8	8	Q**
Quality rating	SD	1.8b	1.9b	2.3ab	2.2ab	2.9a	
	NIL	3.1b*	3.6a*	3.3b*	2.9b*	2.3b*	
				'Summer Snowball'			
Quality rating	SD	0.2b	0b	0.2b	0.1b	1.8a	
	NIL	2.4b*	2.9a*	2.7a*	2.1b*	2.4b*	

[z]Interactions between photoperiod and vernalization significant ($P = 0.05$).

[y]Non-significant (NS) or significant linear (L) or quadratic (Q) trend at $P = 0.01$ (**) or 0.001 (***).

[x]SD = short photoperiods, NIL = night-interrupted lighting.

[w]None of the plants flowered.

[v]Mean separation within columns by single degree of freedom orthogonal contrast, $P = 0.05$, NS = not significant.

[u]Quality rating: 0 = no flowers; 1 = foliage not beyond pot rim, 1–4 flowers and buds (or when all flowers were open if plant had less than five flowers) ; 2 = any one leaf up to 2.5 cm (1 in) beyond pot rim, 5–9 flowers and buds; 3 = any one leaf 5.0 cm (2 in) beyond pot rim, 10–13 flowers and buds; 4 = any one leaf 7.6 cm (3 in) beyond pot rim, 14–17 flowers and buds; 5 = any one leaf greater than 7.6 cm (3 in) beyond pot rim, greater than 17 flowers and buds.

[t]Mean separation for quality ratings in rows (lower case) and columns (*) using interaction t-tests, P = 0.05, from PROC GLIMMIX.

[s]Growth index = (height + widest width + width 90°) / 3; all measurements in cm.

with the highest value occurring after 3 and 6 weeks of VER. 'Silver Princess' showed a facultative requirement for long days to flower, only 70% of plants flowered under SD. Under NIL, quality rating was highest after 0 to 9 weeks of VER, flower shoot number was highest after 3 to 9 weeks of VER, and growth index was largest after 3 and 6 weeks of VER.

'Snow Cap' plants flowered 100% under NIL, regardless of VER, while 49% flowered under SD (Table 1). The interaction between photoperiod and VER was significant for DTF, flower shoot number, growth index, and quality rating (Table 2). DTF decreased linearly with increasing VER under SD and NIL. Plants required 28 and 17 fewer DTF under SD and NIL, respectively, after 12 weeks of VER compared to no VER. Plants under NIL required 20, 13, 9, and 9 fewer DTF after 0, 6, 9, and 12 weeks of VER, respectively, than those under SD. Flower shoot number increased linearly with increasing VER under SD and NIL. Overall, flower shoot number under SD and NIL increased 338 and 131%, respectively, after 12 weeks of VER compared to no VER. Flower shoot number after 0, 6, 9, and 12of weeks of VER were 269, 455, 148, and 95% greater, respectively, for plants under NIL than those under SD. Growth index under SD was not affected by VER , but showed a quadratic response to increasing VER under NIL. There was a 20% increase between lowest and highest values with largest growth index occurring after 6 weeks of VER. Growth index after 0, 6, 9, or 12 weeks of VER were 11, 26, 13, and 10% greater, respectively, for plants under NIL than those under SD. Quality rating was highest after 12 weeks of VER under SD and lowest after 0, 6, or 9 weeks of VER, but there was no difference in quality ratings under NIL. Overall quality ratings under NIL were about 2.9 units greater than those under SD.

'Snow Cap' showed no interaction between photoperiod and VER for shoot height (Table 3). Plants under NIL were 10 cm (4 in) taller at first flower than those under SD. Shoot height changed quadratically with increasing VER with the tallest plants occurring after 3 weeks of VER. 'Snow Cap' showed a facultative requirement for long days to flower; only about 50% of plants flowered under SD. Under NIL, quality rating, flower shoot number, and growth index were highest after 6 weeks of VER and shoot height was greatest after 3 weeks of VER.

'Snow Lady' plants flowered 100% under NIL, regardless of VER, while 69% of plants receiving 3 to 12 weeks of VER

Table 3. Response of five *Leucanthemum* x*superbum* cultivars to vernalization duration and short photoperiod or night-interrupted lighting[z].

			Vernalization (weeks)					
	SD[y]	NIL	0	3	6	9	12	Significance[x]
					‘Silver Princess’			
Days to flower	49*[w]	47	57	54	52	42	39	L***
Shoot height (cm)	21.9	29.0***	27.9	26.2	27.8	23.3	26.2	NS
Growth index[v]	27.5	29.4*	27.9	30.3	30.4	25.9	28.1	Q**
					‘Snow Cap’			
Shoot height (cm)	17.0	27.0***	23.9	26.6	24.3	24.1	21.3	Q*
					‘Snow Lady’			
Days to flower	49*	45	49	52	50	44	39	L***
Shoot height (cm)	18.7	22.9**	22.4	22.8	24.0	17.8	19.6	Q**
Growth index	22.2	23.0[ns]	22.6	24.0	24.9	20.8	21.1	Q***
					‘Summer Snowball’			
Days to flower	54	58[ns]	65	61	58	52	52	L***
Flower shoot number	2	6*	4	7	7	4	5	Q*
Shoot height (cm)	40.3	59.9**	50.3	64.8	62.6	61.0	45.8	Q*
Growth index	32.6	42.1*	38.9	44.6	43.9	42.4	34.2	Q**

[z]Interactions between photoperiod and vernalization not significant ($P = 0.05$).

[y]SD = short photoperiods, NIL = night-interrupted lighting.

[x]Non-significant (NS) or significant linear (L) or quadratic (Q) trend at $P = 0.05$ (*), 0.01 (**), or 0.001 (***).

[w]Significant at $P \leq 0.05$ (*), 0.01 (**), 0.001 (***) or non-significant (ns) based on main effect F test.

[v]Growth index = (height + widest width + width 90°) / 3; all measurements in cm.

flowered under SD, but none of the plants under SD flowered without VER (Table 1). The interaction between photoperiod and VER was significant for flower shoot number and quality rating (Table 2). Flower shoot number was not different under SD, but showed a quadratic change with increasing VER under NIL. There was a 75% increase in flower shoot number between the lowest and highest numbers under NIL with the highest flower shoot number occurring after 6 weeks of VER and the lowest after 0, 9, or 12 weeks of VER. Plants under NIL had 13 and 100% more flower shoots after 3 and 6 weeks of VER, respectively, than under SD. The highest quality ratings under SD occurred after 6 to 12 weeks of VER while the highest ratings under NIL occurred after 3 weeks of VER. Overall quality ratings under NIL were 0.8 units higher under NIL than under SD.

‘Snow Lady’ showed no interaction between photoperiod and VER for DTF, shoot height, or growth index (Table 3). Plants under NIL required 4 fewer DTF and were 4.2 cm (1.7 in) taller at first flower than those under SD but there was no difference in growth index. DTF decreased linearly, while shoot height and growth index changed quadratically with increasing VER. Plants required 11 fewer DTF between the lowest and highest values. The highest values for shoot height and growth index occurred after 6 weeks of VER, 35 and 20% higher than the lowest values, respectively, which occurred after 9 weeks of VER. ‘Snow Lady’ showed a fac-

Table 4. Response of five *Leucanthemum* x*superbum* ‘Becky’ to vernalization duration and natural short photoperiod or night-interrupted lighting[z].

	Vernalization (weeks)					
	0	3	6	9	12	Significance[y]
Days to flower	63	59	56	46	45	L***
Flower shoot number	8	6	8	8	7	Q**
Shoot height (cm)	45.4	57.9	66.1	47.9	61.1	Q**
Growth index	35.0	40.0	43.2	34.8	40.0	Q**
Quality rating[x]	1.7b[w]	2.4a	2.7a	2.8a	2.4a	

[z]No data was recorded from plants under natural short days because none of the plants flowered, therefore the interactions between photoperiod and vernalization not testable.

[y]Significant linear (L) or quadratic (Q) trend at $P = 0.01$ (**) or 0.001 (***).

[x]Quality rating: 0 = no flowers; 1 = foliage not beyond pot rim, 1–4 flowers and buds (or when all flowers were open if plant had less than five flowers) ; 2 = any one leaf 2.5 cm (1 in) beyond pot rim, 5–9 flowers and buds; 3 = any one leaf 5.0 cm (2 in) beyond pot rim, 10–13 flowers and buds; 4 = any one leaf 7.6 cm (3 in) beyond pot rim, 14–17 flowers and buds; 5 = any one leaf greater than 7.6 cm (3 in) beyond pot rim, greater than 17 flowers and buds.

[w]Mean separation for quality ratings in rows using main effect t-tests, $P = 0.05$, from PROC GLIMMIX.

ultative requirement for NIL to flower; only 69% of plants flowered under SD. Under NIL, quality rating and flower shoot number were highest after 3 weeks of VER while shoot height and growth index were highest after 6 weeks of VER.

'Summer Snowball' plants flowered 100% under NIL, regardless of VER, while 31% flowered under SD (Table 1). The interaction between photoperiod and VER was significant for quality rating (Table 2). The highest quality ratings under SD occurred after 12 weeks of VER while the highest ratings under NIL occurred after 3 and 6 weeks of VER. Overall quality ratings under NIL were about 2 units higher under NIL than under SD.

'Summer Snowball' showed no interactions between photoperiod and VER for DTF, shoot height, growth index, or flower shoot number (Table 3). Plants under NIL required 4 fewer DTF, were 19.6 cm (7.7 in) taller, and were 29% larger than those under SD. DTF decreased linearly, while flower shoot number, shoot height and growth index changed quadratically with increasing VER. Plants required 13 fewer DTF after 12 weeks of VER when compared to no VER. The greatest shoot height and growth index occurred after 3 weeks of VER with a 42 and 30% increase, respectively, between lowest and highest values. Flower shoot number was highest after 3 or 6 weeks of VER with 3 more shoots than at the lowest value.'Summer Snowball' showed a facultative requirement for NIL to flower, only 31% of plants flowering under SD. Under NIL, quality rating was highest after 3 weeks of VER, flower shoot number was highest after 3 and 6 weeks of VER, and growth index and shoot height was highest after 6 weeks of VER.

'Becky' plants flowered 100% under NIL, regardless of VER , while none of the plants under SD flowered (Table 4). Days to flower decreased linearly, while flower shoot number, shoot height, and growth index changed quadratically with increasing VER. Plants receiving 12 weeks of VER flowered in 18 fewer days than those receiving no VER. Flower shoot number was highest after 0, 6, or 9 weeks of VER while shoot height was 20.7 cm (8.5 in) taller after 9 weeks of VER than at 0 weeks of VER. There was a 24% increase in growth index between the lowest and highest values with the greatest growth index occurring after 6 weeks of VER. Quality ratings were higher after plants received 6 weeks of VER when compared to no VER. 'Becky' showed an obligate requirement for long days to flower, and plant growth characteristics and quality were improved by 6 to 9 weeks of VER under NIL.

The Shasta daisy cultivars tested in this study varied in response to photoperiod and VER. 'Becky' showed an obligate requirement for NIL regardless of VER to flower 100% with no flowering under SD, while 'Silver Princess', 'Snow Cap', 'Snow Lady', and 'Summer Snowball' showed a facultative response with flowering percentages averaging 70, 49, 69, and 31% under SD and 100% under NIL. 'Silver Princess', 'Snow Cap', 'Snow Lady', and 'Summer Snowball' did not exhibit 100% flowering under SD unless they received 12 weeks of VER, similar to 'G. Marconi' except that 16 weeks of VER were required (12) and similar to 'Snow Cap' that received 15 weeks of VER (9) under SD. 'Silver Princess', 'Snow Cap', 'Snow Lady', and 'Summer Snowball' plants under NIL flowered earlier, were larger, had more flower shoots, and had a higher overall quality rating than plants under SD. In this study, increasing VER decreased DTF in 'Snow Lady' contrary to Damann and Lyons (4) who found fastest flowering in non-vernalized plants. Likewise in this study, 'Snow Cap' flowered fastest under NIL after 12 weeks VER while Runkle et al. (9) found fastest flowering with ≥ 3 weeks of VER.

In 'Silver Princess', 'Snow Cap', 'Snow Lady', and 'Summer Snowball' shoot height and growth index were highest under NIL after 3 and 6 weeks of VER, flower shoot number was highest after 3 to 9 weeks of VER, but DTF was least after 12 weeks of VER. In 'Becky', plant growth characteristics and quality were improved by 6 and 9 weeks of VER under NIL. Therefore, NIL after 3 or 6 weeks of VER would maximize plant size and quality for practical application but result in more DTF when compared to 12 weeks of VER.

Literature Cited

1. Aylsworth, J.D. 1995. Selling perennials in flower. Greenhouse Grower 13(8):14–16.

2. Cameron, A., R. Heins, and W. Carlson. 1996. Forcing perennials 101. Greenhouse Grower 14(3):19–20.

3. Damann, M.P. and R.E. Lyons. 1995. Juvenility and photoperiodic flowering requirements of *Chrysanthemum xsupererbum* 'G. Marconi' and 'Snow Lady' under short- and long-day conditions. J. Amer. Soc. Hort. Sci. 120:241–245.

4. Damann, M.P. and R.E. Lyons. 1996. Natural chilling and limited inductive photoperiod affect flowering of two asteraceae genera. J. Amer. Soc. Hort. Sci. 121:694–698.

5. Floriculture Crops 2005 Summary. 2006. USDA National Agricultural Statistical Service. Sp Cr 6-1 (06).

6. Griffin, C.W. and W.J. Carpenter. 1964. Photoperiodic response of Shasta daisy clones Esther Read and T.E. Killian. Proc. Amer. Soc. Hort. Sci. 85:591–593.

7. Kofranek, A.M. 1952. Producing early daisies with artificial lights. Southern Florists and Nurseryman 65:93–95.

8. Laurie, A. and G.H. Poesch. 1932. Photoperiodism. The value of supplementary illumination and reduction of light on flowering plants in the greenhouse. Ohio Agr. Expt. Sta. Bul. 512:1–42.

9. Runkle, E.S., R.D. Heins, A.C. Cameron, and W.H. Carlson. 1998. Flowering of *Leucanthemum* x*superbum* 'Snowcap' in response to photoperiod and cold treatment. HortScience 33:1003–1006.

10. SAS Institute. 2006. The GLIMMIX procedure, June 2006. SAS Institute, Cary, NC.

11. Schabenberger, O. and F.J. Pierce. 2002. Contemporary Statistical Models for the Plant and Soil Sciences. CRC Press, Boca Raton, FL.

12. Shedron, K.G. and T.C. Weiler. 1982. Regulation of growth and flowering in *Chrysanthemum* x*superbum* Bergmans. J. Amer. Soc. Hort. Sci. 107:874–877.