Night-Interrupted Lighting of Nursery-Grown Herbaceous Perennials in the Southeastern USA©

J. Raymond Kessler, Jr. and Gary J. Keever
Department of Horticulture, 101 Funchess Hall, Auburn University, Alabama 36849, USA
Email: kessljr@auburn.edu; keevegj@auburn.edu

INTRODUCTION

Plant responses to day length were discovered and defined during the first half of the twentieth century. Plants may be classified as short-day, long-day, or day neutral in their response for flowering. Short-day plants are those that initiate flowers when the day length is shorter than their critical day length. Day lengths longer than the critical day length result in vegetative growth. Conversely, long-day plants are those that initiate flowers when the day length is longer than their critical day length. Day lengths shorter than the critical day length result in vegetative growth. The critical day length is the break-point day length above or below which plants perceives long or short days, respectively. These two categories may be further classified as qualitative or quantitative. In a qualitative photoperiodic response, the requirement for a specific photoperiod is absolute for floral initiation. In a quantitative photoperiodic response, flowering is faster or plants have more flowers if provided the correct photoperiod, but plants eventually flower regardless of photoperiod. In day neutral plants, floral initiation is not correlated with photoperiod. Plants initiate flowers after reaching a specific size or stage of development.

Plant responses to photoperiod have been widely applied for forcing greenhouse crops into flower during times of the year that they would not normally flower. Recently, herbaceous perennials have been investigated for their flowering requirements. These may include vernalization (a cold period) and a specific photoperiod, but perennials vary widely in their requirements. Generally, where a vernalization period is required, 6-8 weeks at 4°C (40°F) in cooler [>2°C (>35°F), <7°C (<45°F)] or 8-12 weeks in minimum heated greenhouse has been successful. Like photoperiod, the vernalization requirement may be qualitative or quantitative. As a general rule, herbaceous perennials that normally flower in the early spring do not have a photoperiod requirement for flowering, but often have a vernalization requirement. Those that flower in spring and summer often require long days that must follow vernalization if required. Perennials that flower in the fall often do not have a vernalization requirement, but frequently need short days.

In the southeastern USA, plug-grow herbaceous perennials (seedlings or rooted cuttings) are received and potted into nursery containers in the fall for nursery production. In the winter, plants may be moved into minimum heated greenhouse or provided freezing protection by covering in the nursery. In the spring, plants grow and flower based on ambient conditions for spring and summer sales. Typically, no photoperiod manipulation is practiced. Therefore, plants are marketed as they naturally flower. However, peak retail sales occur during a 4-6 weeks in spring, during April and early May. However, many summer-blooming perennials are not yet naturally in flower.

Ambient temperatures begin to warm early in USDA cold hardiness Zone 8B, often in early February. Therefore, vegetative growth of perennials in containers begins growth long before natural long days would initiate flowers. Our objectives were to determine if night-interrupted lighting could be applied in a nursery setting to force summer-blooming perennials early, and by staggering application, can it be used to bring perennials into flower over an extended period, thus, extending the market period?

MATERIALS AND METHODS

Experiment 1

The research was conducted at the Ornamental Horticulture Substation in Mobile, Alabama USA (USDA cold hardiness Zone 8b, 30.7°N latitude) in 1999-2000. Plug-grown plants of *Achillea* 'Coronation Gold', *Leucanthemum* × *superbum* 'Alaska', *Rudbeckia fulgida* var. *sullivantii* 'Goldsturm', *Scabiosa columbaria* 'Butterfly Blue', and *Verbena canadensis* from 70-cell flats were transplanted into #1 trade gallons with a pine bark:peat (3:1, v/v) medium amended with Osmocote 17-7-12 (17N-3P-10K), dolomitic limestone, gypsum, and Micromax. Plants were grown pot-to-pot outdoors in full sun through the winter under natural photoperiods and watered as needed from overhead impact sprinklers. Plans were made to cover plants with white polyethylene if temperatures approaching -7°C (20°F) were predicted.

A night-interrupted lighting (NIL) block was established in the nursery area to provide a minimum of 10 ft-c of light from 22:00 to 2:00 CST. Incandescent lamps were spaced 1.2 m (4 ft) on center within rows, 1.5 m (5 ft) between rows, and 1.2 m (4 ft) above ground level. A black plastic curtain separated plants receiving NIL from unlighted control plants to a height of 1.8 m (6 ft) to prevent light leakage. The curtain was pulled in place at 16:00 and removed at 8:00 daily beginning 1 February, and continuing until all plants reached the first open flower stage. Plants of each species were moved from the unlighted control area to the NIL area on 1 February, 15 February, 1 March, or 15 March. The date of the first fully-opened flower was recorded. At this time, flower (inflorescence) and floral bud count, plant height from the substrate surface to the uppermost plant part, and growth index [(height + widest width + width perpendicular to widest width) ÷ 3], were determined.

Experiment 2

This experiment was conducted in 2000-2001 and used methods similar to those used in the first experiment except *Coreopsis verticillata* L. 'Moonbeam', *Coreopsis grandiflora* 'Early Sunrise', *C. grandiflora* 'Sunray', *Sedum* × 'Autumn Joy', *Physostegia virginiana* 'Red Beauty', and *Salvia* × *sylvestris* 'Blaukönigin' (syn. *S.* × *superba* 'Blue Queen' were tested.

Experiment 3

This experiment was conducted in 2001-2002 and used methods similar to those used in the first two experiments with the following exceptions. NIL was started on 1 February only. *Coreopsis verticillata* 'Moonbeam' and *R. fulgida* var. *sullivantii* 'Goldsturm' were treated with Cutless® (flurprimidol) at 50, 100, and 150 ppm; B-Nine® (daminozide) at 2500, 5000, and 7500 ppm; B-Nine/Cycocel® (chlormequat) combinations at 2500/1500, 5000/1500, and 7500/1500 ppm; and Bonzi® (paclobutrazol) at 50, 100, and 150 ppm when plants began to elongate vigorously. B-Nine and B-Nine/Cycocel treatments were reapplied on April 2. Treatments also included untreated control plants under NIL. Natural control plants were not treated.

RESULTS

Experiment 1

Compared to the control, night-interrupted lighting (NIL) accelerated flowering of 'Goldsturm' rudbeckia (qualitative long day plants) by 46, 33, 32, and 26 days with the 1 February, 15 February, 1 March, and 15 March start dates, respectively, but had no effect on flower counts, and increased plant height and growth index with 15 February, 1 March, and 15 March start dates (Table 1). Compared to the control, NIL accelerated flowering of 'Coronation Gold' achillea (qualitative long day plant) by 11 days only with a 1 February start date (data not shown). Plants were 59, 37, and 28% taller than controls with 1 February, 15 February, and 1 March start dates, but not with the 15 March start date. Compared to the control, NIL did not accelerated flowering of 'Alaska' leucanthemum (quantitative long day plant), but did increase flower number by 80-140% and plant height and growth index (Table 1). Compared to the control, NIL did not accelerated flowering of 'Butterfly Blue' scabiosa (quantitative long day plant), but did increase flower number by 37-51% and plant height and growth index with the 1 February and 15 February start dates only (data not shown). Compared to the control, NIL did not accelerated flowering of verbena (day neutral plant) or affect flower count, but increase plant height and growth index with the 1 February start date only (data not shown).

Table 1. Effects of night-interrupted lighting on selected containerized herbaceous perennials when grown under U.S.A. nursery conditions in USDA cold hardiness Zone 8b in 1999-2000.

Lighting treatment	Days to flower[z]	Flower and bud count	Plant height (cm)	Growth index[y]
		Rudbeckia fulgida var. *sullivantii* 'Goldsturm'		
Natural	146	13	50.6	37.8
1 February	100*[x]	11	48.9	38.5
15 February	113*	12	60.3*	40.7*
1 March	114*	13	62.1*	42.8*
15 March	120*	14	59.9*	41.2*
Significance[w]	Q***	NS	Q***	Q**
		Leucanthemum × *superbum* 'Alaska'		
Natural	80	5	51.7	41.4
1 February	81	9*	69.4*	52.7*
15 February	79	12*	75.4*	53.0*
1 March	82	11*	70.9*	53.5*
15 March	87	11*	69.6*	52.7*
Significance	NS	NS	NS	NS

[z]Days to flower beginning 1 February 1999.
[y]Growth index = (height + widest width + width perpendicular) ÷ 3, in cm.
[x]Means followed by an asterisk were significantly different from mean for natural treatment.
[w]Nonsignificant (NS) or quadratic (Q) trend at the P=0.01 (**) or 0.001 (***) level; natural treatment not included in analyses.

Experiment 2

Compared to the control, NIL accelerated flowering of 'Moonbeam' coreopsis and 'Early Sunrise' coreopsis (qualitative long day plants) by 36, 21, 15, and 7 days and by 15, 12, 6, and 3 days with 1 February, 15 February, 1 March, and 15 March start dates, respectively, and had a 244 and 61% higher flower counts with a 1 February NIL start date (data not shown). However, plants were about 85 and 31% taller than those under the control with a 1 February NIL start date. Compared to the control, NIL accelerated flowering of 'Autumn Joy' sedum and 'Red Beauty' obedient plant (qualitative long day plant) by 38, 36, 36, and 26 days and by 52, 26, 21, and 20 days, respectively, had a 300 and 46% higher flower counts with a 1 February NIL start date (data not shown). However, there were no differences in plant height for either species. Compared to the control, NIL accelerated flowering of 'Sunray' coreopsis (quantitative long day plants) by 13, 9, and 8 days with 1 February, 15 February, and 1 March start dates, respectively, but not with the later date (data not shown). Plants had 21% greater flower numbers and were 27% taller than those under the natural control with a 1 February NIL start date. Compared to the control, NIL accelerated flowering of 'Blaukönigin' salvia (quantitative long day plants) by 7 and 12 days with 1 February, and 15 February start dates, respectively, but not with the later date (data not shown). Plants had 83% greater flower numbers and were 27% taller than those under the natural control with a 1 February NIL start date.

Experiment 3

NIL decreased tine to visible bud and to flower of 'Moonbeam' coreopsis and 'Goldsturm' rudbeckia and increased plant height when compared to the control (Table 2, rudbeckia not shown). However, plants grown under NIL were taller than plants grown under natural photoperiod. None of the PRGs affected days to visible bud or flower compared to the NIL control in 'Moonbeam' coreopsis, but B-Nine and B-Nine+Cycocel increased these parameters in 'Goldsturm' rudbeckia. Plant height decreased with increasing PGR rate by 49% with Cutless, 33% with B-Nine, 62% with B-Nine+Cycocel, and 6% with Bonzi in 'Moonbeam' coreopsis. All PGRs decreased plant height in 'Goldsturm' rudbeckia with increasing rate in 2003 but not in 2002.

Table 2. Effect of night-interrupted lighting and growth retardants on *Coreopsis verticillata* 'Moonbeam' when grown under USA nursery conditions in USDA cold hardiness Zone 8b in 2002-2003.

Growth retardant[z]	Conc. (ppm)	Days to visible bud	Days to flower	Height (cm)
Cutless	50	61*[y]	78*	36.1*
	100	59*	76*	32.1*
	150	64*	83	27.3
Significance[x]		NS	NS	L***
B-Nine	2,500	61*	79*	32.9*
	5,000	61*	80*	32.1*
	7,500	60*	80*	30.6*
Significance		NS	NS	L***
B-Nine+Cycocel	2,500+1,500	60*	80*	31.0*
	5,000+1,500	59*	78*	26.8
	7,500+1,500	59*	77*	25.1
Significance		NS	NS	L***
Bonzi	50	61*	78*	39.7*
	100	58*	77*	39.5*
	150	61*	80*	38.2*
Significance		NS	NS	NS
NIL		60*	77*	40.6*
Natural control		74	92	23.7

[z]B-Nine (daminozide), Bonzi (paclobutrazol), Cutless (flurprimidol), Cycocel (chlormequat).

[y]Means followed by an asterisk were significantly different from mean for natural treatment.

[x]Nonsignificant (NS) or quadratic (Q) trend at the P=0.01 (**) or 0.001 (***) level; natural treatment not included in analyses.

CONCLUSIONS

Night-interrupted lighting (NIL) can be applied in a nursery setting to force summer-blooming perennials for early markets. The kind and magnitude of the response depends on the photoperiod classification of the herbaceous perennial. Staggered NIL application can also be used to bring perennials in flower over an extended period. However, excessive plant height was a problem in NIL treated plants. There was some success with applying PGRs to control plant height, but more work needs to be done.