Figure 1. Beamflicker

Manipulating Light In the Greenhouse

New technology for long-day lighting has been developed for greenhouse production. How does it stack up to the options currently available?

By Matthew Blanchard and Erik Runkle

During greenhouse production, photoperiod is commonly manipulated to induce or prevent flowering in photoperiodic crops. A photoperiodic response is actually controlled by the length of the night. For example, long-day plants flower when the length of night is short (e.g., less than 10 hours). Many floriculture crops, including bedding plants and herbaceous perennials, are produced in late winter and early spring so they can be scheduled in flower and marketed in the spring. Therefore, when producing crops under natural short days, photoperiodic lighting can induce or accelerate flowering in long-day crops.

To promote flowering in long-day crops, low-intensity lighting can be delivered either as a day-extension, continuous four-hour night interruption (NI), or as cyclic lighting (e.g., six minutes on and 24 minutes off) for four hours during the middle of the night. Incandescent (INC) lamps have been commonly used for long-day lighting because they are inexpensive to install and can be operated cyclically without reducing the lifespan of the bulb. However, INC lamps are energy inefficient and emit a lot of far-red light, which can promote stem extension. Traditional high-pressure sodium (HPS) lamps are more energy efficient but not appropriate for cyclic lighting because frequent on-and-off switching reduces the lifespan of the bulb and ballast.

A new technology for long-day lighting has been commercially developed for greenhouse production. Parsource's Beamflicker consists of a stationary HPS lamp with an oscillating parabolic reflector that rotates 180 degrees to provide an intermittent beam of light over a relatively large growing area (Figure 1). During the past two years, we have performed experiments to determine the effectiveness of the Beamflicker on flower induction in long-day floriculture crops. This article summarizes the results of our studies.

Experimental Setup

The experiments were performed from October to March in East Lansing, Mich., in a glass-glazed greenhouse with natural short-day photoperiods. The air temperature was a constant 68° F. Plugs of campanula (*Campanula carpatica* 'Pearl Deep Blue'), coreopsis (*Coreopsis grandiflora* 'Early Sunrise'), three cultivars of petunia (*Petunia x hybrida* 'Dreams Neon Rose', 'Easy Wave Coral Reef' and 'Wave Purple') and rudbeckia (*Rudbeckia hirta* 'Becky Cinnamon Bicolor') were grown under nine-hour short days, transplanted into 4½-inch pots and placed under lighting treatments.

A four-hour NI was delivered during the middle of the night from either a 600-watt Beamflicker or 60-watt INC lamps. The Beamflicker was mounted 12 feet above greenhouse benches at one gable end of the greenhouse, and 10 plants of each species were grown at lateral distances

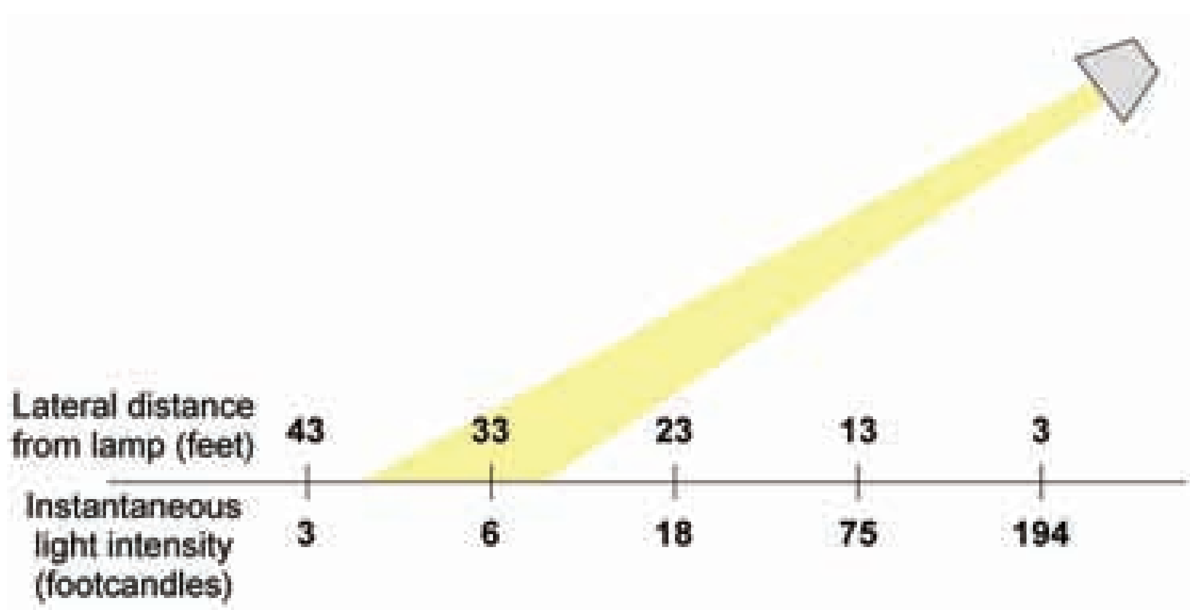

Figure 2. Plants were grown at five lateral distances from under a 600-watt Beamflicker that provided different instantaneous light intensities during a four-hour night interruption.

of 3, 13, 23, 33 and 43 feet from under the lamp. The Beamflicker operated continuously during the four-hour NI. For INC NI lighting, lamps were mounted above the bench and plants were illuminated either continuously for four hours or for six minutes every half hour, for four hours. Control plants were grown under a constant nine-hour photoperiod and did not receive NI lighting. Opaque black cloth was extended from 5 p.m. to 8 a.m. every day on benches with INC lighting and control plants.

Results

As the lateral distance from the Beamflicker increased from 3 to 43 feet, the light intensity measured at plant level decreased from 194 foot-candles to 2 foot-candles (Figure 2). The maximum light intensity measured under INC lamps was 15 foot-candles.

No campanula, coreopsis, rudbeckia or petunia 'Wave Purple' plants flowered when grown under a nine-hour short day, indicating that these crops require long days for flowering. Petunias 'Easy Wave Coral Reef' and 'Dreams Neon Rose' flowered at a similar or earlier time under NI treatments compared to plants under short days.

The flowering response to the NI treatments varied among species. All plants except petunia 'Wave Purple' flowered at all distances from the Beamflicker. At 43 feet from the Beamflicker, only 20 percent of petunia 'Wave Purple' flowered, and flowering was delayed in other crops. For example, campanula grown at 43 feet from the Beamflicker flowered nine days later than plants grown nearly directly below (3-foot lateral distance) the Beamflicker (Figure 3). In petunia 'Wave Purple', as the distance from the Beamflicker increased from 3 to 33 feet, time to flower increased from 43 to 61 days (Figure 4).

At all lateral distances from the Beamflicker, flowering was delayed in coreopsis (by 14 to 31 days), petunia 'Dreams Neon Rose' (by three to eight days) and rudbeckia (by eight to 20 days) compared to under a four-hour NI delivered continuously from INC lamps. Flowering of all crops except coreopsis was delayed by five to 20 days when grown under INC lamps that operated cyclically compared to plants under INC lamps that were on continuously during the four-hour NI.

Petunias 'Easy Wave Coral Reef' and 'Wave Purple' were 1.2 to 3.3 inches taller at open flower when grown under the continuous four-hour INC NI compared to ➧

plants under the Beamflicker. The increased stem elongation under INC lamps was not unexpected: They emit a lower ratio of red light to far-red light compared to HPS lamps. When more far-red than red light is exposed to plants, stem elongation is promoted.

Conclusions

All crops except petunia 'Wave Purple' flowered when the Beamflicker provided NI; however, plants closest to the Beamflicker flowered earlier than plants grown farther away. The delay in flowering at this distance may not be desirable for growers who need to schedule a crop to flower uniformly. At distances greater than 23 feet from the Beamflicker, the light intensity measured was less than 10 foot-candles, which, when provided intermittently, was inadequate for the most rapid and uniform flowering in petunia 'Wave Purple'. However, most commercial greenhouses would need to operate multiple Beamflickers for their growing area. Light from adjacent Beamflickers would also provide some light to crops, which would increase the effective distance between lamps.

The light intensity under the Beamflicker is influenced by the

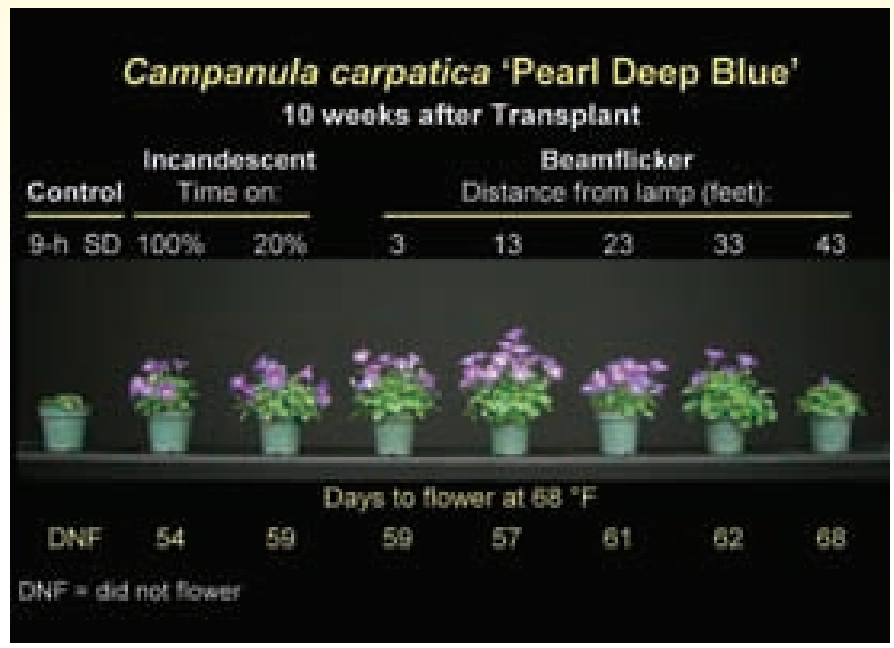

Figure 3. Effects of four-hour night interruption (NI) lighting with incandescent (INC) lamps or a Beamflicker on flowering of campanula 'Pearl Deep Blue'. Plants were grown at five lateral distances from under a 600-watt Beamflicker or under 60-watt INC lamps. INC lamps operated continuously for the entire NI (100% on) or for 6 minutes every 30 minutes (20% on) for a four-hour period. Control plants were grown under a constant nine-hour short day (SD) and did not receive NI lighting.

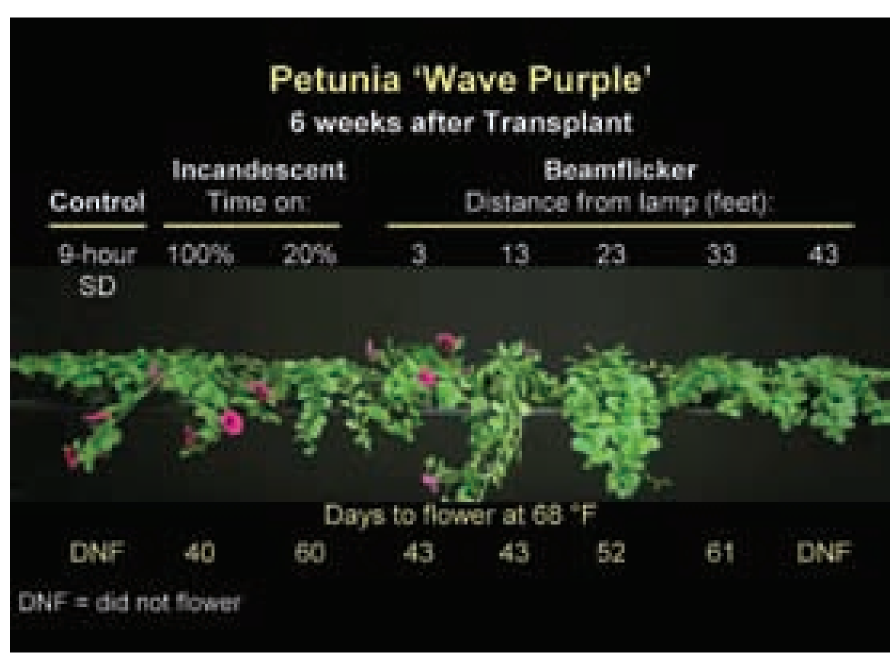

Figure 4. Effects of four-hour night interruption (NI) lighting with incandescent (INC) lamps or a Beamflicker on flowering of petunia 'Wave Purple'. Plants were grown at five lateral distances from under a 600-watt Beamflicker or under 60-watt INC lamps. INC lamps operated continuously for the entire NI (100% on) or for 6 minutes every 30 minutes (20% on) for a four-hour period. Control plants were grown under a constant nine-hour short day (SD) and did not receive NI lighting.

	Incandescent (100 watt)	Beamflicker (600 watt)
Fixtures per 1500 ft² growing area	40	1
Electrical Costs		
Electrical energy consumed per fixture	100 watts	673 watts*
Electricity used per 1500 ft² growing area	4 kilowatts	0.673 kilowatts
Electricity used per week (lamps on 4 hours/day)	112 kilowatt-hours	18.8 kilowatt-hours
Electrical cost per week ($0.10 per kWh)	$11.20	$1.88
Bulb Costs		
Bulb cost	$0.60	$40.00
Bulb lifespan (hours)	750	24,000
Bulb life if operated for 28 hours per week	27 weeks	857 weeks
Bulb cost per 1500 ft² growing area per week	$0.89	$0.05
Total operating cost per 1500 ft² growing area per week	$12.09	$1.93

** Includes a 600-watt bulb, 70-watt ballast and 3-watt oscillating reflector.*

Table 1. *Comparison of operating costs to deliver four-hour night interruption lighting in a 1,500-square-foot growing area from either 100-watt incandescent lamps or a 600-watt Beamflicker (cyclic high-pressure sodium lamp). Purchase, installation and maintenance costs for the lamps should also be considered.*

lamp's mounting height and wattage, and structural objects that may intercept light before reaching the crop. In our greenhouse, a 600-watt Beamflicker mounted 12 feet above a crop would be sufficient to light a 50x30-foot greenhouse with at least 10 foot-candles. Light from adjacent Beamflickers would increase this size by approximately 50 percent.

A big advantage of using a Beamflicker for long-day lighting is the savings in electrical costs, because fewer lamps would be needed compared to INC to deliver low-intensity lighting. For example, long-day lighting of a 1,500-square-foot greenhouse with a Beamflicker for four hours each night would save 84 percent in operating costs each week compared to the same greenhouse with 40 INC lamps at 100 watts each (Table 1).

We conclude that a Beamflicker can be used effectively to induce or accelerate flowering in long-day crops and to save on electrical costs. In the spring, long-day lighting should be provided until April 15, after which the natural day length is long enough to promote flowering of most long-day species. GPN

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