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Some greenhouse growers have found success using a combination of compact fluorescent and incandescent lamps to provide night interruption lighting.

Providing Long-Days with CFLs

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Can compact fluorescent lamps save energy and still light your crops adequately?

In floriculture crop production, growers often use long-day photoperiods when the days are naturally short to promote flowering of long-day plants or to inhibit flowering of short-day plants. Replacing incandescent (INC) lamps with compact fluorescent (CFL) lamps has been recommended to reduce energy consumption. CFL lamps have decreased dramatically in cost, are typically 75% more energy efficient than INC lamps and can be easily retrofitted into existing INC lighting fixtures. In addition, plants grown under CFL lamps can be shorter than those under INC lamps, which can reduce the need for plant growth retardants.

However, the quality of light emitted by CFL lamps is quite different than that of INC lamps. Specifically, CFL lamps emit much less far-red (FR) (700 to 800 nm) light than INC lamps (Table 1). Therefore, the ratio of red (R) (600 to 700 nm) to FR light (R:FR) emitted by CFL lamps is substantially higher (8.4) versus that of INC lamps (0.6). When CFL lamps are used in combination with INC lamps (50% lamps of each type), the R:FR is 0.9, which is similar to the R:FR of sunlight.

Long-day photoperiods can be delivered as day-extension lighting (lamps are turned on from sunset to midnight) or night-interruption lighting (typically lamps are turned on from 10 p.m. to 2 a.m.). Previous research has shown that when long days were provided by day-extension lighting with INC or CFL lamps, flowering responses of some long-day perennials were similar. However, flowering of some long-day plants was delayed when night interruption lighting had a high R:FR, such as that under CFL lamps. The objective of this study was to quantify the efficacy of night interruption lighting on flowering of long-day plants using CFL lamps alone or in combination with INC lamps.

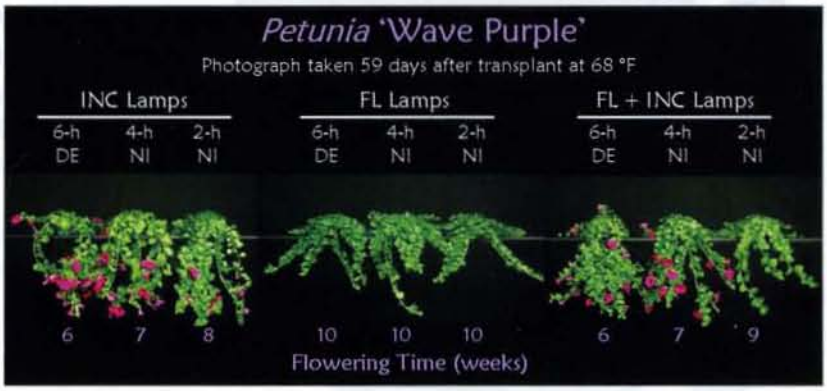
Experimental set-up

Seedlings of campanula Deep Blue Clips, coreopsis Early Sunrise, petunia Wave Purple and rudbeckia Becky Orange were grown in 128-cell plugs in growth chambers under a nine-hour photoperiod. When plugs were deemed marketable, they were transplanted into 4- or 5.5-in. pots containing a peat-based medium. Plants then grew in a

Table 1. Intensity of red (R) (600 to 700 nm) and far red (FR) (700 to 800 nm) light, R to FR ratio (R:FR) and photosynthetic light (PPF) (400 to 700 nm) under incandescent (INC), compact fluorescent (CFL), or a combination of 50% CFL and 50% INC (CFL + INC) lamps.

	Light intensity under the lamps ($\mu mol \cdot m^{-2} \cdot s^{-1}$)*			
Lamp type	R	FR	R:FR	PPF
INC	1.5	2.5	0.6	2.3
CFL	1.1	0.1	8.4	2.2
CFL + INC	2.0	2.1	0.9	3.5

*Light intensity rounded off to one digit



glass greenhouse set at 68F (20C). Plants received a nine-hour photoperiod created by pulling blackcloth over all treatments from 5 p.m. to 8 a.m. Nine different lighting treatments were provided by 60-watt INC and 13-watt CFL lamps, either alone or combined. Lamps were operated for six hours as a day extension (15-hour photoperiod) or for two or four hours during the middle of the night (2- or 4-hour night interruption). The lamps were installed about 3 ft. above the greenhouse benches with approximately 3 ft. between each lamp. As a control, an additional short-day treatment (nine-hour photoperiod without lighting) was included.

The data collection included flowering percentage after 15 weeks of growing, time to first open flower at 68F (20C), plant height at flowering, and several environmental measurements. Here, we present results from the first set of experiments on some of the species studied.

Figure 1. Flowering responses of petunia Wave Purple under the nine long-day lighting treatments. All plants received a nine hour photoperiod prior to the long-day lighting and night interruption treatments were provided during the middle of the night. DE = day extension, NI = night interruption, INC = incandescent and CFL = compact fluorescent.

Results and discussion

All of the plants presented here are obligate long-day plants, and as expected, none flowered under the nine-hour short-day treatment. Rudbeckia flowered under all the lighting treatments tested (Table 2). Most (but not all) of the campanula and coreopsis flowered at about the same time. In addition, lamp type did not affect the heights of campanula and rudbeckia at flowering. Coreopsis grown under the day-extension lighting treatment with CFL lamps were 21% shorter than the remaining treatments.

Nearly all petunia plants flowered when CFL lamps provided day extension or four-hour night inter-

Table 2. Final flowering percentages of long-day plants under the long-day lighting treatments. INC = incandescent; CFL = compact fluorescent; SD = 9-hour short days; DE = day extension lighting; and NI = night interruption lighting.

Species		Campanula	Coreopsis	Petunia	Rudbeckia
SD		0	0	0	0
INC Lamps	DE	80	90	100	0
	4-hourNI	90	60	100	100
	2-hour NI	100	90	100	100
CFL Lamps	DE	80	80	100	100
	4-hourNI	100	80	90	100
	2-hourNI	100	90	40	100
CFL + INC	DE	80	90	100	100
	4-hourNI	100	80	100	100
	2-hourNI	100	70	100	100

ruption lighting, but only 40% of the plants flowered when provided with a two-hour night interruption (Figure 1). When long days were provided by INC lamps, alone or in combination with CFL lamps, all petunias flowered. Providing day-extension lighting with CFL lamps delayed flowering of petunias by four weeks compared with that under INC lamps. Flowering of petunias was also delayed by two to three weeks when night interruption was provided by CFL lamps. Combining CFL lamps with INC lamps largely overcame this delay in flowering. The lamp type did not influence the flowering height of petunias.

Conclusions

Based on our results, CFL lamps can be used effectively to provide long-day photoperiods to campanula Deep Blue Clips, coreopsis Early Sunrise and rudbeckia Becky Orange. In petunia Wave Purple, flowering was inhibited or delayed under CFL lamps. However, this inhibition was overcome when CFL lamps were combined with INC lamps. Therefore, the flowering response of long-day plants to day-extension and night-interruption lighting provided by CFL lamps is species-specific, and may even be cultivar specific.

We are evaluating the flowering responses of additional long-day plants, a few short-day plants (to inhibit flowering) and other petunia cultivars. We caution growers against switching entirely to CFL lamps for photoperiodic lighting given the flowering delays that can occur in some crops, such as petunias. In addition, you should determine the purchase and operating costs for INC and CFL lamps to determine which option is more economical for your production. Consistent with our data, some bedding plant growers who recently switched to alternating CFL lamps with INC lamps have reported desirable results. **GT**

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