Effects of a New Cyclical Lighting System on Flower Induction in Long-Day Plants: A Preliminary Investigation

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INTRODUCTION

During commercial production of many floriculture crops, photoperiod is often manipulated to induce or prevent flowering in photoperiodic species. The photoperiodic response is primarily determined by the duration of darkness (Thomas and Vince-Prue, 1997). To promote flowering in long-day (LD) crops under natural short-day photoperiods, the period of darkness can be truncated by providing night interruption (NI) lighting. NI lighting is most effective at inducing complete and uniform flowering in LD species when plants are illuminated with ≥2 $\mu mol \cdot m^{-2} \cdot s^{-1}$ for 4 h continuously during the middle of the dark period (e.g., 2200 to 0200 HR) (Runkle et al., 1998). In some species such as *R. fulgida* 'Goldstrum', a 1- or 2-h NI delayed flowering by 22 d compared to a 4-h NI (Runkle et al., 1998). Another NI lighting strategy is to provide cyclic or intermittent lighting (e.g., 6 min on and 24 min off) for 4 h during the middle of the dark period.

A new technology for greenhouse LD lighting was developed by Tinus (1995) and was recently commercialized for greenhouse applications. This lighting system consists of a stationary high-pressure sodium (HPS) lamp with an oscillating parabolic reflector (cyclic HPS lamp) (**Fig. 1**). The reflector provides an intermittent beam of light over a relatively large growing area. The cyclic HPS lamp has been reported to be effective at preventing seedling dormancy in several coniferous species when used during the night (Tinus, 1995). However, to our knowledge, no scientific reports have been published that compare the efficacy of a cyclic HPS lamp on flower induction in LD floriculture crops with traditional NI lighting strategies.

Figure 1. Stationary high-pressure sodium (HPS) lamp with an oscillating parabolic reflector (cyclic HPS lamp) (*top*) and an example of the cyclic HPS lamp operating during the experiment (*bottom*).

MATERIALS AND METHODS

Plant material. *Asclepias tuberosa*, *Campanula carpatica* 'Pearl Deep Blue', *Coreopsis grandiflora* 'Early Sunrise', *Petunia* 'Easy Wave Coral Reef', and *Rudbeckia hirta* 'Becky Cinnamon Bicolor' were grown in a glass-glazed greenhouse at a constant temperature of 20 °C with natural short-day photoperiods (January to April at 43 ºN lat.) and three NI treatments.

Treatments. NI lighting was delivered from 2200 to 0200 HR from a 400-W cyclic HPS lamp (Beamflicker; Parsource, Petaluma, California, USA) mounted at one gable end of the greenhouse or from 60-W incandescent (INC) lamps that were illuminated for the entire 4 h or for 6 min every 30 min for 4 h. Plants under cyclic HPS were grown at lateral distances of 1, 3, 7, 10, or 13 m from the lamp (**Fig. 1**). Control plants were grown under a constant 9-h photoperiod and did not receive NI lighting. Opaque black cloth was retracted from 1700 to 0800 HR every day on benches with INC NI lighting and control plants. After 11 weeks in treatments, all plants with a VB were transferred to a constant 9-h photoperiod.

Light measurements. The maximum photosynthetic photon flux (*PPF*) was measured at each lateral distance from the cyclic HPS lamp and under INC lamps using a portable spectroradiometer (LI-1800, LI-COR, Inc., Lincoln, Nebraska, USA) oriented in a horizontal position. Light measurements were collected at each lateral distance from the cyclic HPS lamp by first stopping the oscillating reflector and then positioning the reflector so that light from the lamp was directed towards each treatment.

RESULTS

- Thirty-five days after the beginning of the experiment, the reflector on the cyclic HPS lamp stopped oscillating because of a loose bolt in the gearing mechanism, although the lamp continued to turn on from 2200 to 0200 HR. Therefore, the results of this experiment are considered preliminary.
- As the lateral distance from the cyclic HPS lamp increased from 1 to 13 m, the maximum *PPF* decreased exponentially from 20.9 to 0.4 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (**Fig. 2**). The maximum *PPF* measured under INC lamps was 3.2 $\mu mol \cdot m^{-2} \cdot s^{-1}$.
- During the 32 d when the reflector remained stationary, all plants except those located at a lateral distance of 13 m from the lamp received a similar *PPF* during NI lighting, 1.2 to 2.8 $\mu mol \cdot m^{-2} \cdot s^{-1}$, while plants located at 13 m from the cyclic HPS lamp received <0.5 $\mu mol \cdot m^{-2} \cdot s^{-1}$ during NI lighting.
- In all species except *Asclepias* and *Coreopsis,* cyclic HPS or INC lamps induced complete flowering of the plant populations in each treatment (**Fig. 3**).
- In *Campanula*, *Petunia*, and *Rudbeckia*, flowering was delayed by 7 to 12 d when the INC lamps operated cyclically compared to being operated during the entire 4 h of the NI treatment.
- When grown under the 9-h photoperiod, *Campanula*, *Coreopsis*, and *Rudbeckia* remained vegetative after 11 weeks, and vegetative growth of *Asclepias* essentially ceased.
- The number of VB, height at flower, and increase in node number varied among species and treatments (data not presented).

Figure 3. The effects of 4-h night interruption (NI) lighting on flowering in five herbaceous species. Plants were grown at five lateral distances from a high-pressure sodium (HPS) lamp with an oscillating parabolic reflector or under incandescent lamps. Incandescent lamps operated continuously for the entire NI (100%) or for 6 min every 30 min for a 4-h period (20%). Control plants were grown under a constant 9-h photoperiod without NI lighting. Photographs were taken 10 weeks after the start of the experiment and visible flower bud percentages were calculated after 11 weeks in treatments.

CONCLUSIONS

- Although the reflector on the cyclic HPS lamp stopped operating 35 d after the start of the experiment, these preliminary results indicate that all species grown at lateral distances of up to 13 m from the lamp perceived the NI lighting as displayed by the characteristic long-day growth habit (e.g., upright leaves and elongated stems).
- The maximum *PPF* measured at a lateral distance of 13 m from the cyclic HPS lamp was 0.4 $\mu mol \cdot m^{-2} \cdot s^{-1}$ and is apparently above the threshold irradiance value to elicit a photoperiodic flowering response in these species.
- An HPS lamp with an oscillating reflector can be used effectively to promote flowering in the LD species studied. Because of the malfunction in the cyclic HPS lamp, we recommend that commercial growers using this new lighting system routinely check the reflector and lamp to make sure both are operating properly.

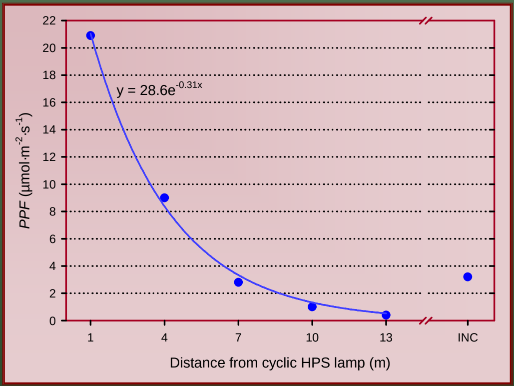

Figure 2. Maximum photosynthetic photon flux (*PPF*) measured at five lateral distances from a stationary high-pressure sodium lamp with an oscillating parabolic reflector (cyclic HPS) and under an incandescent lamp (INC). The reflector on the cyclic HPS lamp was oriented towards each treatment when measurements were collected.

LITERATURE CITED

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