

Lighting Research

BY QINGWU MENG & ERIK S. RUNKLE

Control Flowering with LEDs

Is it worth paying extra for LEDs? Researchers at Michigan State University found that the long-term benefits may outweigh the up-front costs.

Flowering of many popular ornamental crops is determined by day length. When the natural days are short, low-intensity lighting during the middle of the night (night interruption, NI) or at the end of the day promotes flowering of long-day plants and inhibits flowering of short-day plants. For long-day plants, a 4-hour NI is recommended for the most rapid and uniform flowering.

Conventional broad-spectrum light sources, such as incandescent (INC) and high-pressure sodium (HPS) lamps, are effective at creating long days. However, INC lamps are very energy inefficient and are being phased out of production. HPS lamps are more energy efficient, but in most commercial installations, they deliver a higher intensity than needed to regulate flowering and consume a large amount of electricity. Light-emitting diodes (LEDs) potentially consume less energy, enable delivery of specific colors of light, and in many cases, have a very long operating life. For the past three years, one of the major research thrusts at Michigan State University (MSU) has been to better understand how different colors of light, delivered by LEDs, regulate flowering.

As part of this project, we have been experimenting with LEDs recently developed by Philips Lighting. Philips currently produces three types of screw-in LED lamps with potential flowering applications and include deep red (DR), white (W) and/or far-red (FR) LEDs:

- FR only
- DR+W
- DR+W +FR

The 14-watt DR+W+FR LED lamp was developed as a commercial replacement for 100 or 150-watt incandescent lamps used for photoperiodic lighting. The DR+W lamp was developed for crops that don't



Figure 1. Setup of treatments, including a natural short day and a 4-hour night interruption from incandescent or the Philips deep red + white + far red (DR+W+FR) LEDs, at the Center for Applied Horticulture Research at Altman Plants.

need FR light for flowering, which includes most short-day plants. Without the FR light, plants are typically shorter. However, because flowering of some crops is regulated by R and FR light, the DR+W+FR lamp was developed for use on all day length-sensitive crops.

From January to June 2013, we coordinated commercial greenhouse grower trials to investigate the efficacy of the Philips DR+W+FR LEDs at controlling flowering of day length-sensitive bedding plants. The participating companies were C. Raker & Sons (Litchfield, Michigan), the Center for Applied Horticultural Research (CfAHR) at Altman Plants (Vista, California), Henry Mast Greenhouse (Byron Center, Michigan), Krueger-Maddux Greenhouses (Sunman, Indiana) and Kube Pak (Allentown, New Jersey). The trials were also performed in two separate greenhouses at MSU. Based on previous research performed at MSU, we postulated that the DR+W+FR lamps were at least as effective as conventional lamps for regulating flowering.

Grower trial protocol

Seeds of ageratum Hawaii Blue, dianthus Telstar Crimson, petunia Easy Wave Burgundy Star and Wave Purple Classic, snapdragon Liberty Classic Yellow and verbena Obsession were sown in 288-cell plug trays and cuttings of calibrachoa Callie and dahlia Dahlinova Texas were propagated in 51-cell strip trays by C. Raker & Sons. These plants were sown at the same time and shipped to all participating growers in late January. The typical young plant production durations were shortened by one week in an attempt to ship vegetative (non-induced) plants.

Upon receipt, each grower transplanted the plants into 1801 trays using their typical growing media for bedding plant production and placed four trays of each crop under each treatment. All plants were grown under similar environmental conditions following the growers' standard production practices of watering, fertilization and pest management. The average daily temperature ranged from 62F (16C) at

Krueger-Maddux Greenhouses to 71F (21C) at CFAHR. The average daily light integral (DLI) ranged from 9 mol·m⁻²·d⁻¹ at Henry Mast Greenhouse to 20 mol·m⁻²·d⁻¹ at CFAHR. Applications of plant growth retardants were at the discretion of the growers, and if an application was made, it was the same in all treatments.

The plants were grown under natural short days at all locations except for MSU, where 9-hour short days were provided. Two different 4-hour NI lighting treatments were delivered by the DR+W+FR LEDs or conventional lamps that the growers had used previously. INC lamps were used at Krueger-Maddux Greenhouses, Kube Pak, CFAHR and MSU, while HPS lamps were used at C. Raker & Sons and Henry Mast Greenhouse. CFAHR delivered a natural short day (Figure 1), MSU delivered a 9-hour short day and Kube Pak delivered a 4-hour NI by compact fluorescent (CFL) lamps. Depending on location, the lamps were installed 3 to 7 ft. above the plant canopy and 3 to 10 ft. apart. All lamps operated from 10:00 p.m. to 2:00 a.m. every night. If two treatments were close together, a light barrier was pulled at night to block all direct light from adjacent treatments.

Date of transplant and date of the first open flower were recorded for 12 random plants of each crop under each treatment. Plants were checked every day or two for first flowering at most locations, or once or twice a week at Kube Pak. Flowering percentage and days to flower were calculated for each treatment and additional flowering data were recorded for the treatments at MSU.

Grower trial results

C. Raker & Sons—All plants flowered under either the HPS lamps or LEDs. There was no significant impact of lamp type on flowering time for any crop except for verbena, which flowered approximately eight days earlier under the HPS lamps than under the LEDs. This could be at least partially attributed to a higher average daily temperature (by 4 degrees F) and DLI (by 4 mol·m⁻²·d⁻¹) under the HPS lamp treatment.

CFAHR—All crops under the INC lamps and LEDs flowered at approximately the same time, whereas some of the long-day plants did not flower under the natural short days. For ageratum, dahlia, dianthus, petunia Easy Wave Burgundy Star and verbena, there were no differences in flowering time among all treatments, probably because the natural photoperiod and/or DLI in Vista, California, were sufficient for flower induction. Calibrachoa and snapdragon flowered earlier under the NI lighting treatments than under short days (Figure 2).

Henry Mast Greenhouse—All plants flowered similarly under the HPS lamps and LEDs, except only 8% of snapdragon under the HPS lamps had flowered when the trial ended.

Krueger-Maddux Greenhouses—All plants flowered similarly under the INC lamps and LEDs except for >>>



Figure 2. Calibrachoa and snapdragon grown under natural short days without or with a 4-hour night interruption from incandescent or the Philips deep red + white + far red (DR+W+FR) LEDs at the Center for Applied Horticulture Research at Altman Plants. Average days to flower followed by different letters (in white font) are significantly different. Flowering percentage is in yellow font.

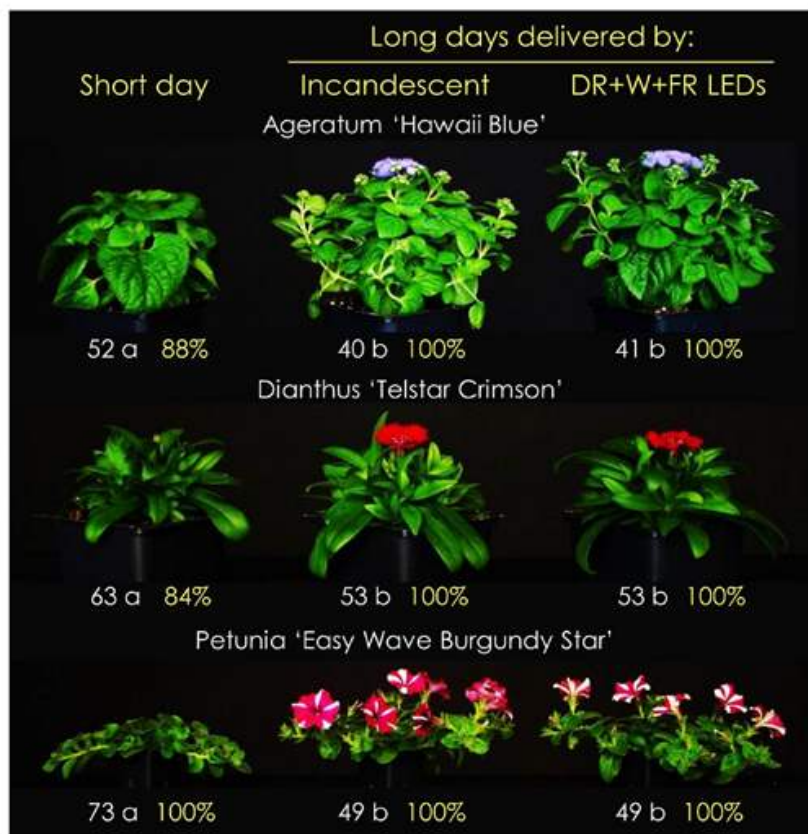


Figure 3. Ageratum, dianthus and petunia grown under 9-hour short days without or with a 4-hour night interruption from incandescent or the Philips deep red + white + far red (DR+W+FR) LEDs at Michigan State University. Average days to flower followed by different letters (in white font) are significantly different. Flowering percentage is in yellow font.

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snapdragon, which flowered approximately eight days earlier under the INC lamps than under the LEDs.

Kube Pak—Petunia Wave Purple Classic did not flower under the CFL lamps before the trial ended. We have previously shown that CFLs are not very effective at inducing flowering of petunias, as well as a few other long-day plants. For ageratum, dahlia, dianthus and snapdragon, flowering time was similar among all treatments. Petunia Easy Wave Burgundy Star and verbena flowered earlier under the LEDs than under the INC lamps. Calibrachoa flowered earlier under the LEDs than under the CFL and INC lamps.

MSU—Ageratum, dianthus, petunia Easy Wave Burgundy Star and Wave Purple Classic, and snapdragon flowered similarly under the INC lamps and LEDs and earlier than under short days (Figure 3). The flowering responses of calibrachoa and dahlia were inconsistent in the two greenhouses. Verbena flowered earlier under the INC lamps and LEDs than under short days; but

in one greenhouse, flowering was the most rapid under the INC lamps. Except for dahlia and petunia Wave Purple Classic, plant height at flowering was similar under the INC lamps and LEDs. For example, the stem with the first flower of petunia Wave Purple Classic was approximately 2 in. longer under the LEDs than under the INC lamps.

Conclusions

With a few exceptions, flowering of the bedding plant crops tested was similar under the Philips DR+W+FR LEDs as under the conventional lamps. Therefore, we conclude that in most instances, the DR+W+FR LEDs are as effective as lamps traditionally used in greenhouses. Given the comparable effectiveness of the LEDs and conventional light sources, factors such as energy consumption, lamp longevity and investment payoff should be considered.

The DR+W+FR LEDs are more efficient than most types of conventional

lamps, since they only consume 14 watts per lamp. The useful lifetime of these LEDs at 77F (25C) and 90% intensity is at least 20,000 hours, while that of incandescent bulbs is usually around 1,000 hours. The greater energy efficiency and much longer lifetime should be weighed against the higher purchase price of the LEDs versus incandescents. Given our research findings, the efficacy of the LEDs should not be a factor. **GT**

Qingwu (William) Meng is an M.S. student and **Erik Runkle** (runkleer@msu.edu) is an associate professor and floriculture extension specialist in the Department of Horticulture at Michigan State University. The authors thank C. Raker & Sons, the Center for Applied Horticultural Research at Altman Plants, Henry Mast Greenhouse, Krueger-Maddux Greenhouses and Kube Pak for their cooperation with this project. They also thank Philips Lighting and HortAmericas for subsidizing the cost of the LEDs and funding provided by the USDA National Institute of Food and Agriculture's Specialty Crop Research Initiative and MSU's Project GREEN.