Blooming by Lamplight

BY CALEB SPALL AND ROBERTO LOPEZ

Michigan State University studied the flowering responses of long-day plants under various screw-in LED lamps.

Many greenhouse crops flower in response to day length and will only flower, or flower faster, when the proper photoperiod is provided. Photoperiodic crops are categorized as short-day plants (SDPs) or long-day plants (LDPs), where days shorter or longer than a critical photoperiod induce flowering, respectively. Conversely, day-neutral plants do not flower in response to day length.

These classifications can be further broken down into facultative (quantitative) or obligate (qualitative) SDPs or LDPs, where a day length shorter or longer than a plant's critical photoperiod greatly accelerates flowering or is required for flowering, respectively.

Regardless of the location of your growing operation, photoperiodic lighting or light blocking curtains (black cloth) can be used to provide photoperiods to induce or inhibit flowering of daylength sensitive crops. Traditionally, incandescent lamps (INC) alone or in combination with compact fluorescent lamps (CFLs) were used to create long days (LDs) through low-intensity day extension (DE) or night-interruption (NI) lighting. However, INC lamps have been phased out of production due to

Figure 1. Non-horticultural LED lamps installed in this greenhouse have filled up with water.

their short life span and energy inefficiency.

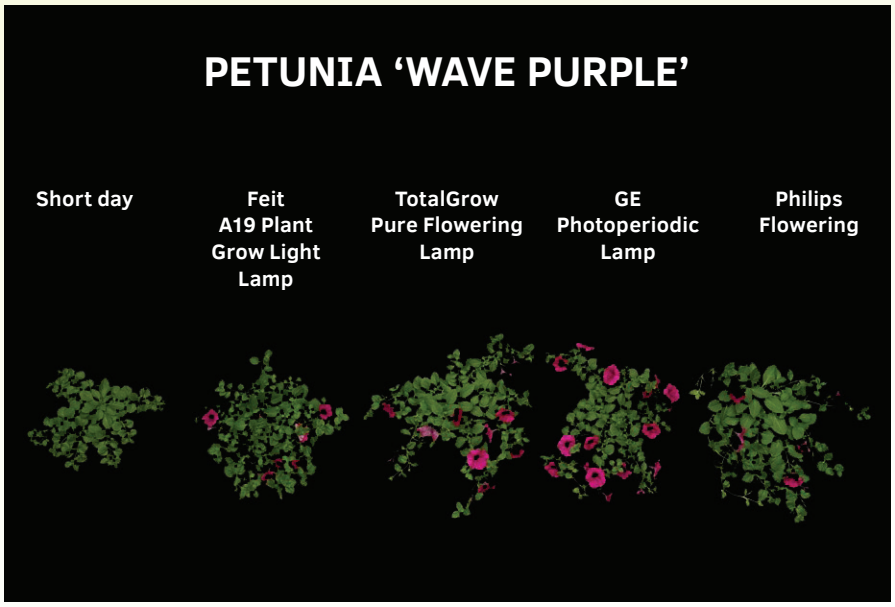
DE and NI lighting emitting 2 to 3 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of red (R; 600-700 nm) radiation is sufficient at inhibiting flowering of most SDPs and promoting flowering of some, but not all, LDPs. Therefore, both R and far-red (FR; 700-800 nm) radiation must be applied together to promote flowering in most LDPs.

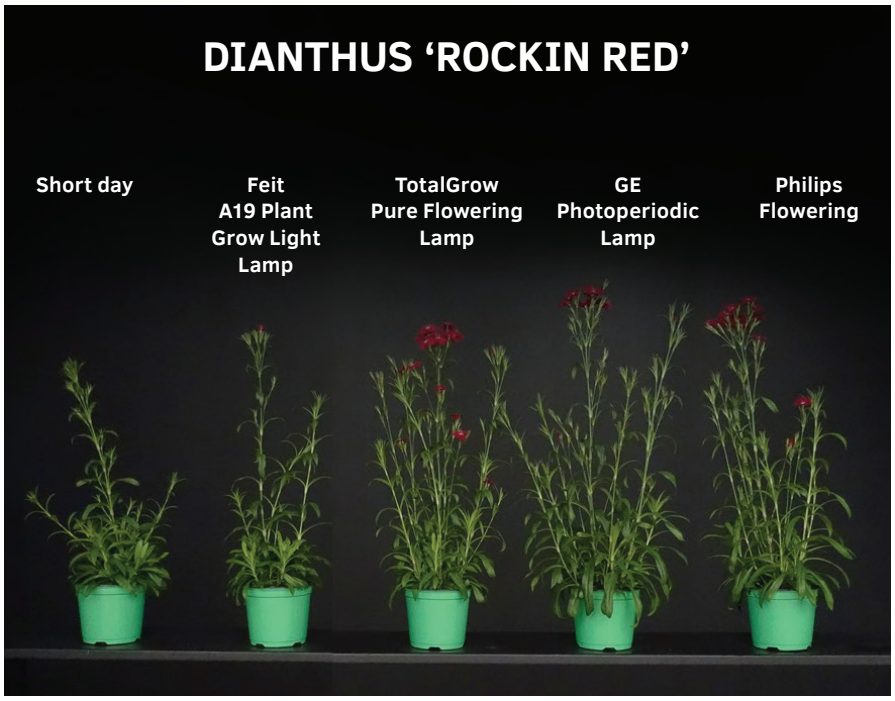
Previous MSU research has determined that off-the-shelf cool-white and warm-white light-emitting diodes (LEDs) for home lighting applications can induce flowering of most, but not all LDPs (see https://gpnmag.com/article/evaluating-different-colors-leds-control-flowering for more information).

A variety of low-intensity screw-in LEDs designed for commercial greenhouse or home gardening applications are currently on the market, each providing unique wavelengths (color, light quality or spectrum) of light. The potential exists for greenhouse growers to significantly reduce their energy costs with horticultural LED lamps tailored with specific spectra to hasten flowering of LDPs and potentially reduce stem elongation compared to INC lamps.

Given the numerous options, which lamps should growers select given that the cost of each LED lamp can vary from $10 to over $45 each? Why not just use an inexpensive white LED screw-in lamp if they will induce most LDPs into flower?

Figure 2. Low-intensity LED lamps used in the study.





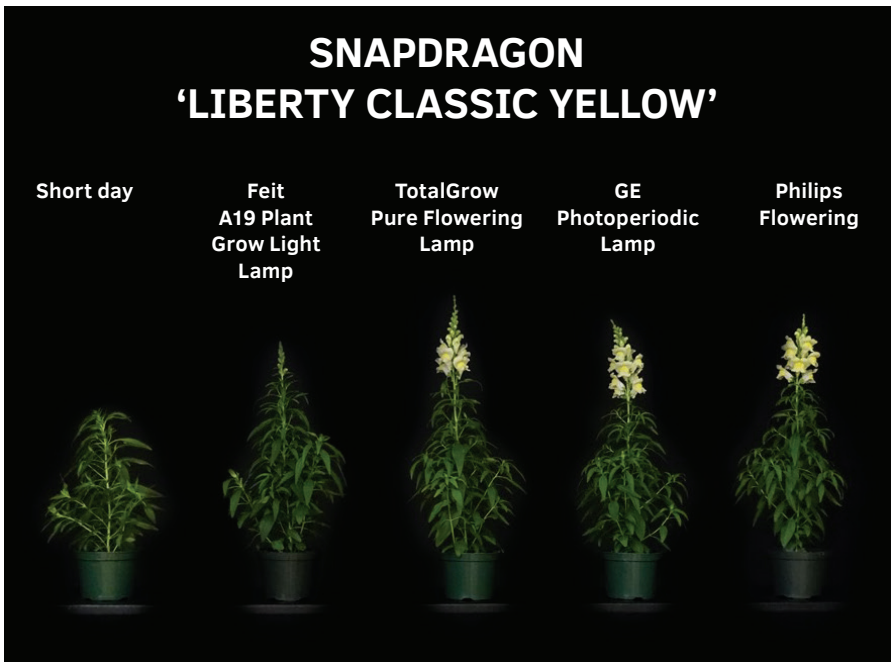


Figure 3. (A) Flowering responses of petunia ‘Wave Purple’, (B) snapdragon ‘Liberty Classic Yellow’, and (C) dianthus ‘Rockin Red’ placed under a 9-h short day, or under 4-h night interruption lighting from 10 p.m. to 2 a.m. from a 9-W non-dimmable A19 LED; Feit Electric, 16-W TotalGrow pure flowering 200 lamp, 10-W GE Arize Greenhouse Pro photoperiodic LED lamps or 13-W Philips GreenPower LED flowering lamps.

For one, most LED screw-in fixtures for home or office use are not designed for high-humidity, wet and high temperature conditions as can be seen in Figure 1. In this example, moisture has penetrated and accumulated inside the lamp, rendering it useless and unsafe. Additionally, different lamps provide different wavelengths, which can influence time to flower and finished quality of your crop. In this article, we will focus on the flowering and growth responses of several facultative and obligate LDPs to low-intensity screw-in LEDs providing different light qualities.

WHAT DID WE FIND?

We grew calibrachoa ‘Kabloom Pink’ (*Calibrachoa x hybrida*), dianthus ‘Rockin Red’ (*Dianthus chinensis x barbatus*), ornamental oregano ‘Kirigami’ (*Origanum x hybrida*), petunia ‘Wave Carmine’, petunia ‘Wave Purple’ (*Petunia x hybrida*), snapdragon ‘Liberty Classic Yellow’, and snapdragon ‘Solstice Yellow’ (*Antirrhinum majus*) under five different treatments, consisting of a nine-hour short day (SD) created by closing opaque black cloth at 5 p.m. and opening it the following morning at 8 a.m., or nine-hour SDs with various screw-in horticultural LED lamps providing 2 to 3 $\mu mol \cdot m^{-2} \cdot s^{-1}$ during a four-hour NI from 10 p.m. to 2 a.m. LED treatments consisted of 9-W non-dimmable plant grow lights (A19 LED; Feit Electric, Pico Rivera, California), 16-W TotalGrow pure flowering 200 lamps (TG1B-1104 Bulb; Venntis Technologies LLC, Holland, Michigan), 10-W Arize Greenhouse Pro photoperiodic LED lamps (General Electric Lighting; Cleveland, Ohio), or 13-W GreenPower LED flowering lamps (DR/W/FR; Philips, Eindhoven, The Netherlands) (Figure 2). The Feit, TotalGrow, Philips, and GE lamps provided a light ratio (%) of 18:27:46:9, 1:2:40:57, 8:13:35:44, and 5:18:47:30 of blue, green, red, and far-red light, respectively. The R:FR ratios of the treatments were 5.1, 0.7, 1.6, and 0.8, respectively.

Plants were monitored daily for the presence of visible flower buds and first open flowers (OF). On the date of OF, the number of nodes below the first OF were recorded for each plant. Additionally, plant height and total number of initiated inflorescences were recorded.

FLOWERING RESPONSES

All of the LED lamps we tested, regardless of emission spectrum, were successful at promoting flowering of the facilitative and obligate LDPs tested. For calibrachoa, oregano, petunia ‘Wave Purple’, and snapdragon ‘Solstice Yellow’, the Philips and GE lamps slightly hastened flowering (1-3 days) compared to the other photoperiodic lighting treatments. Flowering of dianthus, petunia ‘Wave Carmine’, and snapdragon ‘Liberty Classic Yellow’ was hastened by 6, 11, and 7 days, respectively, when grown under the Philips lamps compared to the Feit lamps (Figure 3). Time to flower was similar for dianthus and snapdragon ‘Liberty Classic Yellow’ grown under all photoperiodic lighting treatments except the Feit lamps (Figure 3). Petunia ‘Wave Carmine’ flowered 4 and 8 days faster when grown under the Philips compared to the GE or TotalGrow lamps. While calibrachoa, oregano, and petunia ‘Wave Carmine’ did not flower under SDs, photoperiodic lighting hastened flowering of dianthus, petunia ‘Wave Purple’, snapdragon ‘Liberty Classic Yellow’ and ‘Solstice Yellow’ by up to 7, 23, 17 and 8 days, respectively (Figure 3).

Calibrachoa, dianthus, oregano, petunia ‘Wave Purple’, and snapdragon ‘Solstice Yellow’ had a similar number of nodes below the first OF regardless of treatment. Petunia ‘Wave Carmine’ and snapdragon ‘Liberty Classic Yellow’ grown under Philips lamps had seven and eight fewer nodes, respectively, than those grown under the Feit lamps. Height of dianthus, oregano and snapdragon were not commercially different between photoperiodic lighting treatments.

Moreover, oregano and snapdragon had a similar number of initiated inflorescences at OF regardless of the photoperiodic lighting treatment they were grown under. However, dianthus grown

under SDs or the Feit lamps had an average of 21 inflorescences while those grown under Philips, GE, or TotalGrow lamps had an average of 16, 18 and 19 inflorescences, respectively (Figure 3). Moreover, petunia 'Wave Carmine' had 22 inflorescences when grown under the Feit lamps while those grown under the Philips , GE, or TotalGrow lamps had an average of 10, 14 and 18 inflorescences, respectively.

GREENHOUSE IMPLICATIONS

These findings are consistent with previous research conducted at MSU that indicate that LDPs are most effectively induced to flower under photoperiodic lighting with emission spectra with a moderate combination of R and FR radiation, while too much R or FR radiation can delay flowering or promote stem elongation. Our findings were consistent with this research: the GE (R:FR = 0.8), TotalGrow (R:FR = 0.7) and Philips lamps (R:FR = 1.6) consistently hastened flowering compared to the Feit lamps (R:FR = 5.1).

Additionally, the photoperiodic lighting treatments did not strongly influence plant height at OF or node count at OF for most of the cultivars tested. However, petunia 'Wave Carmine' and snapdragon 'Liberty Classic Yellow' plants under the Feit lamps produced up to seven and eight more nodes, respectively, then those grown under the other treatments. The increased node and inflorescence count for plants grown under the Feit LEDs can be attributed to the delay in flowering compared to the other lamps.

Out of the different photoperiodic lamps we studied, the Philips and GE lamps consistently hastened flowering and produced shorter, though marketable, plants with fewer nodes than the other treatments. The TotalGrow lamps moderately hastened flowering compared to the Feit lamps, however, not as much as the other treatments. Conversely, flowering was consistently delayed under the Feit lamps.

To conclude, while the goals of your own greenhouse operation must be considered when investing in photoperiodic lighting, we recommend that you select horticultural-grade LED lamps that emit moderate amounts of both R and FR radiation, as they have proven successful at regulating flowering in LDPs. gpn

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