TECHNOLOGY

How Adding Far-Red Radiation to Supplemental Lighting Affects Plugs

Michigan State University researchers determine the minimum duration of far-red radiation required during plug production to induce long-day requiring plants into flower after transplant.

By Annika E. Kohler and Roberto G. Lopez

ABOUT THE AUTHORS
Annika Kohler (kohlera3@msu.edu) is an M.S. student, and Roberto Lopez (rglopez@msu.edu) is an Associate Professor and Controlled Environment/ Floriculture Extension Specialist in the Department of Horticulture at Michigan State University (MSU).

It is now common practice for greenhouse growers to use supplemental lighting from high-pressure sodium (HPS) lamps during plug production to provide a daily light integral (DLI) of 8 to 12 mol·m^{-2}·d^{-1}. However, growers are interested in switching to light-emitting diode (LED) supplemental lighting fixtures due to the energy savings, efficacy, long life span, potential rebates, and ability to provide specific light qualities. It is estimated that only 4% to 6% of greenhouses in the U.S. have installed LED supplemental lighting fixtures. Most report fixture costs, uncertainty of which radiation qualities (wavelength) to select, and how crop timing and plant quality will be influenced as reasons for not yet installing LED fixtures.

The majority of fixed spectrum LED supplemental lighting fixtures on the market provide either a mixture of blue (B) and red (R) radiation with or without green (G) radiation (white LEDs). This can potentially affect subsequent flowering of long-day plants grown as either young or finished plants. Flowering of long-day plants is accelerated when supplemental and photoperiodic lighting provide a long day that includes a low R to far-red (FR) radiation ratio. HPS lamps provide a mixture of B, G, R, and FR radiation, which allows growers to force long-day annuals and perennials into flower for spring market dates. Therefore, growers are concerned about investing in LEDs that may or may not contain FR radiation.

Previous MSU research has been conducted to determine how growth and subsequent flowering of young plants is influenced when grown under HPS lamps or fixed spectrum LED fixtures with or without FR radiation. However, the length of time and intensity of FR radiation (µmol·m^{-2}·s^{-1}) in supplemental lighting required to promote flowering of long-day requiring annuals at the seedling stage is largely unknown. Thus, our objective was 1) to determine if LED supplemental lighting providing 70 µmol·m^{-2}·s^{-1} of B and R radiation, with or without FR radiation for different durations would reduce time to flower of long-day annuals and not result in excessive stretch compared to traditional HPS lamps, and 2) to determine the minimum duration of FR radiation exposure to induce subsequent flowering

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Figure 1. **(From top to bottom) Seedlings of *Calibrachoa* 'Kabloom Light Pink Blast', *Petunia* 'Wave Carmine Velour', and snapdragon 'Liberty Classic Yellow' 28 days after being placed under supplemental lighting treatments.** Photos: Annika Kohler

The Experiment

Plant material. Seeds of facultative long-day *Calibrachoa* 'Kabloom Light Pink Blast' and *Petunia* 'Wave Carmine Velour', obligate long-day Snapdragon 'Liberty Classic Yellow' and day-neutral *Impatiens* 'Accent Premium Red' were sown in 160-cell trays at Raker-Roberta's Young Plants (Litchfield, MI). One week later, trays were moved to glass-glazed greenhouse compartments at Michigan State University (MSU). Seedlings were hand irrigated as needed with reverse osmosis water supplemented with water-soluble fertilizer that provided 60 ppm nitrogen.

Growing environment. Plug trays were placed under each of six lighting treatments that included a control (9-hour short day with no supplemental lighting) and five supplemental lighting treatments provided by either HPS or LED fixtures. Supplemental lighting treatments provided 70 µmol·m^{-2}·s^{-1} of blue:red ($B_{20}R_{80}$) or blue:red:far-red ($B_{15}R_{40}FR_{15}$) from high-intensity 325-watt LED fixtures (LumiGrow Pro 325) or blue:green:red:far-red $B_4G_{35}R_{26}FR_5$ from 400-watt HPS lamps (P.L. Light Systems). The subscripted number next to the radiation quality (i.e., B) is the radiation intensity in µmol·m^{-2}·s^{-1} (more information is available in a table online). A 16-hour photoperiod was maintained as fixtures were on from 6 a.m. to 8 a.m. and 5 p.m. to 10 p.m. and only on between 8 p.m. to 5 p.m. when the outside photosynthetic photon flux density was below ≈440 µmol·m^{-2}·s.$^{-1}$

After four weeks, plugs were transplanted into containers filled with soilless media and finished in a greenhouse with a temperature set point of 68°F and a 16-hour photoperiod.

Here's What We Found

Stem elongation. Surprisingly, neither HPS nor LED treatments affected the height of seedlings, with the exception of snapdragon 'Liberty Classic Yellow', which was 0.2 to 1.4 inches taller when grown under LEDs providing $B_{20}R_{80}$ for 14 days and $B_{15}R_{40}FR_{15}$ for 14 days or $B_{15}R_{40}FR_{15}$ for 28 days total compared to all other treatments (Figure 1, page 60).

Stem elongation of *Petunia* 'Wave Carmine Velour' at first open flower

Figure 2. ***Calibrachoa* 'Kabloom Light Pink Blast' after four (top) or five weeks (bottom) of growing in a common finishing environment.**

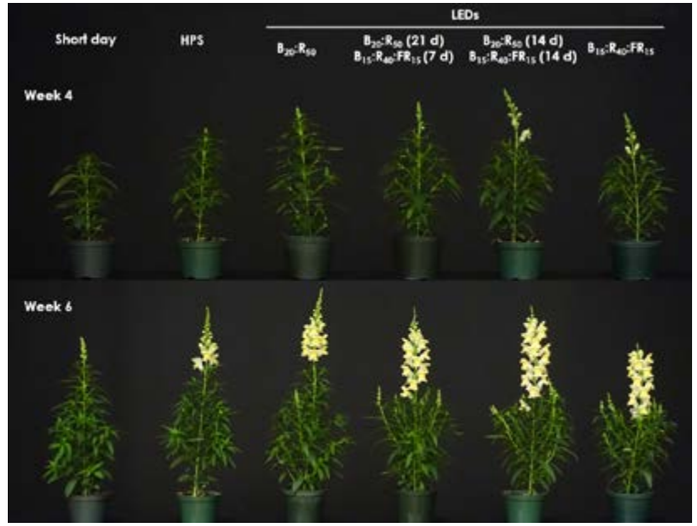

Figure 3. **Snapdragon 'Liberty Classic Yellow' at four (top) and six weeks (bottom) of growing into a common finishing environment.**

was greatest when seedlings were grown under $B_{15}R_{40}FR_{15}$ LEDs for 28 days compared to HPS lamps, $B_{20}R_{50}$ LEDs for 28 days, or $B_{20}R_{50}$ LEDs for 21 days with $B_{15}R_{40}FR_{15}$ LEDs for seven days. Interestingly, the height of snapdragon 'Liberty Classic Yellow' at first open flower was 11% to 35% shorter when grown under LEDs, providing at least two weeks or more of FR radiation compared to all other treatments (Figure 3, page 61).

Time to flower. Flowering of *Impatiens* 'Accent Premium Red' was not influenced by any of the supplemental lighting treatments provided during plug production. This is not surprising, as they are day-neutral plants. However, time to flower of *Calibrachoa* 'Kabloom Light Pink Blast', a facultative long-day plant, was reduced by three days when plugs were grown under $B_{50}R_{50}$ LEDs for 21 days followed by $B_{50}R_{50}FR_{50}$ for seven days compared to seedlings grown under HPS lamps and all other FR LED treatments (Figure 2, page 61). In contrast, all *Petunia* 'Wave Carmine Velour' flowered within two days of each other no matter the treatment. Snapdragon 'Liberty Classic Yellow' on the other hand flowered six and eight days earlier when plugs were grown under $B_{15}R_{40}FR_{15}$ LEDs for 28 days compared to HPS lamps and $B_{20}R_{50}$ LEDs, respectively (Figure 3).

Take-Home Message

Although stems of calibrachoa, petunia, and snapdragon grown under LEDs containing FR radiation were either as tall as seedlings grown with HPS lamps or taller than all other treatments, it did not appear to negatively impact finished plant quality. In fact, the final stem length of snapdragon was correlated to time to flower, with earlier flowering plants having shorter stems. Additionally, time to flower of calibrachoa and snapdragon either decreased or was similar to HPS lamps when grown with LEDs containing FR radiation. However, different results in stem length and time to flower may occur under higher DLIs during the plug or finish stages than what is presented in this study.

Overall, the use of LED supplemental lighting fixtures containing approximately 20% FR radiation can be a viable alternative to HPS lamps, especially when producing long-day plants. There is also implication for increasing the number of crop cycles given the reduction in time to flower when seedlings are grown for at least two weeks under LEDs containing FR. GG

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