ASCFG Research Update - Manipulating Day Length and Light Quality to Improve the Greenhouse Production of Specialty Cut Flowers

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In recent years, burgeoning demand for locally-grown specialty cut flowers has encouraged year-round production across the United States (U.S.). While some regions of the U.S. permit outdoor production year-round (i.e. California), northern regions experience low temperatures and light intensities during the winter and early spring, inhibiting outdoor production. To combat this, growers in these regions can utilize controlled-environment greenhouses to provide proper environmental conditions for high-quality specialty cut flower production, allowing for year-round sales and consumer satisfaction.

Of the environmental parameters that can be controlled within greenhouses, light duration (photoperiod) and light intensity are of critical importance for regulating flowering and overall finished cut flower quality of some species. This is especially true in the northern U.S. during the winter and early spring when the daylength is short, limiting what varieties of cut flowers can be grown without daylength regulation. For instance, popular cut flowers that flower when the daylength is >12 h (long-day plants; LDPs), including snapdragon (*Antirrhinum majus*) and stock (*Matthiola incana*) may not flower as quickly, or flower at all, without daylength extension. Moreover, cut flowers grown under light-limiting conditions may produce fewer and thinner harvestable stems compared to cut flowers grown with sufficient light. Additionally, the spectrum of light emitted from supplemental lighting (SL) sources can vary between fixtures, and can have profound impacts on cut flower development time and finished quality when the solar light intensity is low. Literature regarding the influence of the greenhouse lighting environment on cut flower growth and development is limiting. Therefore, we sought to determine the influence of photoperiod delivered during the seedling stage on the growth responses of marigold 'Xochi' (*Tagetes erecta*) cut flower seedlings, and finished cut flower quality. We also sought to quantify the influence of SL quality on the growth and developmental responses of godetia 'Grace Rose Pink' (*Clarkia amoena*), snapdragon 'Potomac Royal' (*Antirrhinum majus*), and stock 'Iron Rose' (*Matthiola incana*) cut flowers.

In our research greenhouses, we grew 160-cell marigold 'Xochi' seedlings for four weeks under 9-, 11-, 12-, 13-, 14-, 15-, 16-, 18-, and 24-h photoperiods, or a 4-h night interruption (NI) from 10 PM to 2 AM. These lighting treatments were maintained by truncating the natural daylength to 9 h with retractable blackcloth and extending the daylength or interrupting the dark period with low-intensity screw-in light-emitting diode (LED) lamps that provided an intensity of 2 to 3 $\mu mol \cdot m^{-2} \cdot s^{-1}$. High-intensity LED SL fixtures provided ≈120 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of light from 8 AM to 5 PM to maintain a moderate light intensity. We maintained an average daily temperature (ADT) of 68 °F (20 °C), with day temperatures of 72 °F (22 °C) and night temperatures of 64 °F (18 °C).

We found that the photoperiod delivered during the seedling stage did not influence the number of nodes or leaves that seedlings developed after 4 weeks. Additionally, no seedlings had any visible flower buds after four weeks under treatments. However, seedling height increased from 4.4 to 6.2 inches (11.3 to 15.7 cm) as the photoperiod increased from 9 to 24 h.

After four weeks, 20 seedlings each from the 9-, 13-, 14-, 15-, 16-, and 18-h photoperiods were transplanted into bulb crates and placed under a common 12-h photoperiod, to quantify the effects of the seedling photoperiod on the developmental and growth responses during the remainder of the crop cycle (Fig. 1). Time to visible bud and open flower, flower diameter, branch number, and stem caliper of finished cut flowers were similar regardless of seedling photoperiod. We considered cut flowers marketable if stems were >26 inches (65 cm) in length with their terminal flower head 50% open. Stems harvested from plants grown under 9-h seedling photoperiods were an average of 5.7 inches (14.6 cm) shorter at harvest compared to those grown under 15-h seedling photoperiods. However, all harvested stems were longer than 27.6 inches (70 cm). Moreover, plants that were grown under 9-, 13- , and 14-h photoperiods as seedlings yielded slightly fewer marketable stems than those 15-, 16-, and 18-h photoperiods.

Fig. 1. Marigold 'Xochi' plants after being transplanted into bulb crates and placed under a common 12-h photoperiod for finishing.

Based on our findings, relatively compact marigold seedlings can be grown under 9- to 12-h photoperiods, or a 4-h NI, meaning that these seedlings may hold up better during transplant. Longer finished stems can be achieved when seedlings are grown under 13- to 18-h photoperiods.

Supplemental Light Quality Study

Bulb crates containing godetia, snapdragon, and stock seedlings were placed in one of six greenhouses, each with supplemental lighting (SL) fixtures of a differing light spectra. SL fixtures operated at an intensity of 120 $\mu mol \cdot m^{-2} \cdot s^{-1}$ for 12 h for four weeks, after which flowering was induced by extending the daylength to 16 h for the remainder of the crop cycle. SL treatments, defined by their 100-nm wavebands of blue (B), green (G), red (R), and far-red (FR) radiation (photon flux density in $\mu mol \cdot m^{-2} \cdot s^{-1}$), were $B_7G_{60}R_{44}FR_9$, $B_{20}G_{50}R_{45}FR_5$, $B_{30}G_{25}R_{65}$, $B_{20}R_{85}FR_{15}$, R_{120}, or B_{120}. The first treatment was created with high-pressure sodium (HPS) fixtures, whereas the others were created with high-intensity LED fixtures (Fig. 2). The air ADT set points in each greenhouse compartment was 60 ºF (16 ºC) [day/night 65/55 ºF (18.5/13 ºC)].

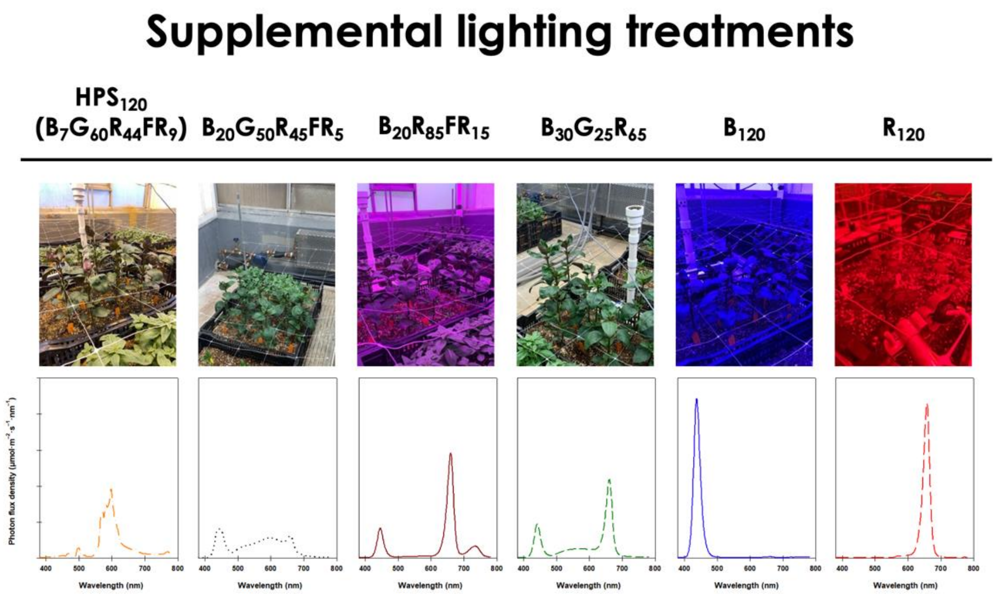

Fig. 2. Supplemental lighting treatments defined by their individual wavebands' photon flux densities ($\mu mol \cdot m^{-2} \cdot s^{-1}$), perception to the human eye, and spectral distribution curves.

Generally, time to visible bud, open flower, and harvest was the fastest under $B_7G_{60}R_{44}FR_9$ (HPS fixtures), $B_{20}R_{85}FR_{15}$, and B_{120} SL, while R_{120} SL delayed these parameters for all genera studied. For instance, time to harvest of godetia, snapdragon, and stock was 9, 18, and 9 d slower, respectively, when grown under R_{120} SL compared to $B_{20}R_{85}FR_{15}$ SL. Flowering was delayed slightly for plants grown under either broad-spectrum treatment ($B_{20}G_{50}R_{45}FR_5$, $B_{30}G_{25}R_{65}$) although not as drastically as R_{120} SL.

Additionally, stem lengths were up to 6, 16, and 6% longer, respectively, for godetia, snapdragon, and stock grown under R_{120} SL compared to $B_{20}R_{85}FR_{15}$ SL. The influence of SL treatment on time to harvest and stem length at harvest of snapdragon 'Potomac Royal' is depicted in Fig. 3. Snapdragon grown under R_{120} SL had up to 23% more branches at harvest than those grown under $B_{20}R_{85}FR_{15}$ SL. Stem caliper was similar for godetia and stock regardless of treatment, though stock stem caliper was 14% thinner when grown under B_{120} SL compared to the other treatments. Flower petal color, when assessed with a colorimeter, was not commercially different between SL treatments. Based on our findings, we recommend growing cut flowers under SL emitting a spectrum similar to $B_{20}R_{85}FR_{15}$, or either broad spectrum, to elicit desirable crop responses while allowing for sufficient human visibility. While high-pressure sodium SL produced high-quality cut flowers, we recommend utilizing LED fixtures for their superior energy efficiency and reduced operating costs.

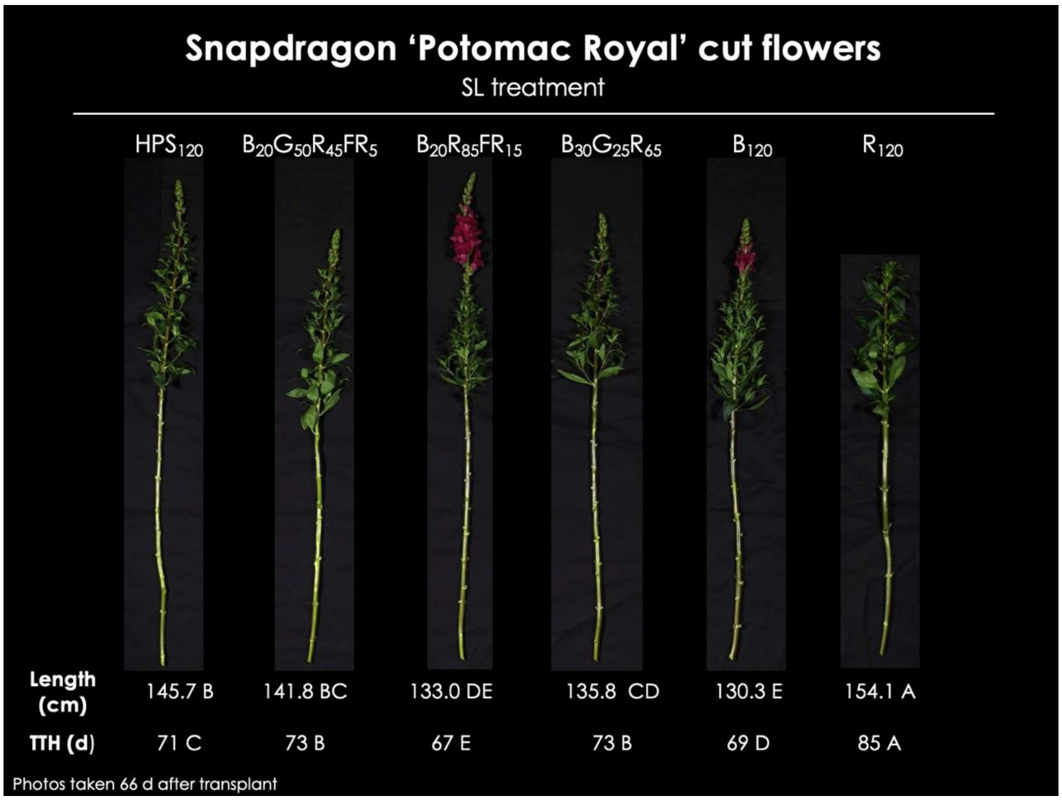

Fig. 3. The influence of supplemental lighting treatment on time to harvest (d) and stem length at harvest (cm) of snapdragon 'Potomac Royal' (*Antirrhinum majus*) cut flowers.

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