Manipulating Daylength and Light Intensity to Improve the Greenhouse Production of Specialty Cut Flowers

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Specialty cut flowers growers in temperate regions cannot produce crops outdoors year-round due to harsh temperatures and low light intensities during the winter. However, consumer demand for a consistent supply of locally-grown specialty cut flowers persists. In order to keep up with increasing market demand for locally-grown specialty cuts, growers must utilize greenhouses equipped with electric lighting to provide adequate daylengths and light intensities to control flowering responses, or increase plant growth and yield, respectively.

Many plants flower in response to the daylength, or photoperiod. These plants can be categorized as either long- or short-day plants, with long days (>12 hours) or short days (<12 hours) promoting flowering, respectively. These categories can be broken down further into obligate or facultative responses, meaning that a specific daylength is required for flowering to occur, or flowering is accelerated under a specific daylength, respectively. Lastly, plants that flower regardless of daylength are categorized as day-neutral plants.

Additionally, as light intensity is the driving force for photosynthesis and thus plant growth and yield, it is critical to maintain sufficient light intensities during seasons when the daylength is short and overcast conditions exist in order to produce high-quality cut flowers. Daylength and light intensity are of paramount importance when it comes to growing high-quality specialty cut flowers (flower size and number, and stem diameter and length) in greenhouses year-round; however, to our knowledge, limited cultural information regarding photoperiodic and supplemental lighting of greenhouse-grown specialty cut flowers exists.

Therefore, we sought to determine the juvenile period in which seedlings cannot be induced into flower and the daylength responses during the seedling (young plant) and flowering (finishing) stages of marigold 'Xochi' (*Tagetes erecta*); witchgrass 'Frosted Explosion' (*Panicum capillare*); and dianthus 'Amazon Neon Cherry' and 'Amazon Rose Magic' (*Dianthus barbatus* interspecific). We also quantified the influence of light intensity on yield and finished quality of witchgrass and both cultivars of dianthus.

In our research greenhouses, seedlings and flowering plants were grown at an average daily temperature of 68 °F (20 °C), with day temperatures of 72 °F (22 °C) and night temperatures of 64 °F (18 °C). We utilized low-intensity light-emitting diode (LED) screw-in lamps providing 2 to 3 $\mu mol \cdot m^{-2} \cdot s^{-1}$ to either extend the natural daylength to various points throughout the night (day-extension lighting), or to provide a night interruption (NI) of four hours from 10 PM to 2 AM (Fig. 1). To create our light intensity treatments, we used high-intensity LED supplemental lighting fixtures providing 120 $\mu mol \cdot m^{-2} \cdot s^{-1}$ from 8 AM to 5 PM to create a moderate light intensity. To maintain low light intensities similar to those found in northern latitudes in the winter, shade cloth was extended over individual benches (Fig. 2)

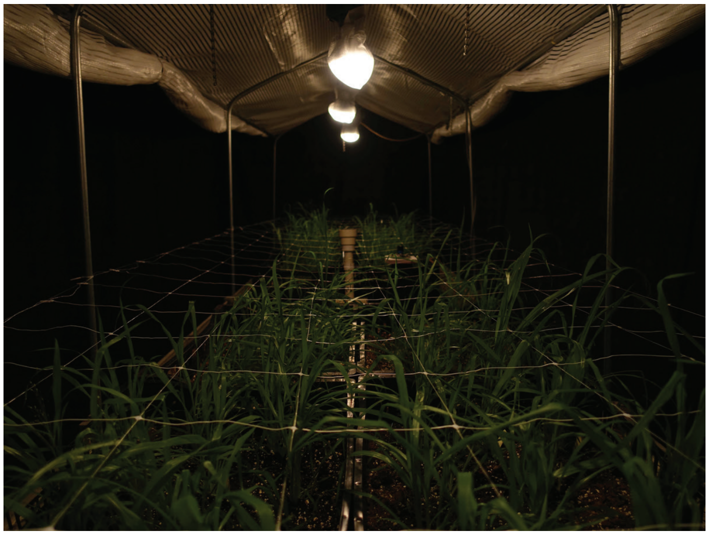

Fig. 1. Low-intensity screw-in LED lamps were utilized to provide various day-extension photoperiods or a 4-h night interruption from 10 PM to 2 AM

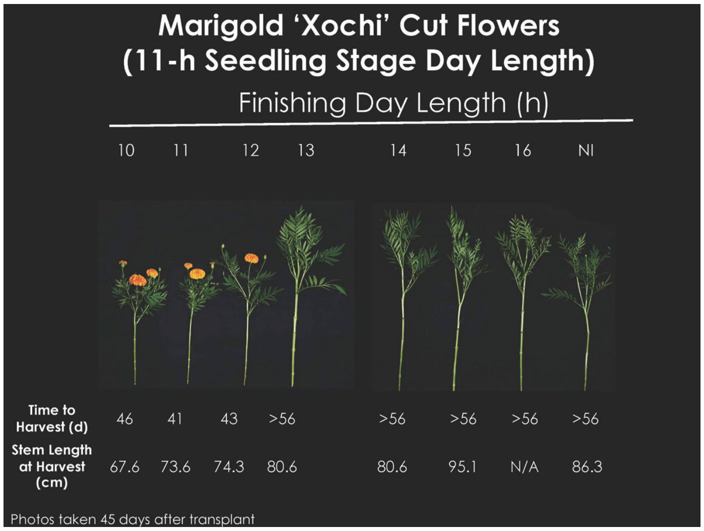

Fig. 2. Moderate light intensities were created with high-intensity LED supplemental lighting, and low light intensities were created with shade cloth stretched above benchtops.

We found that marigold overcame juvenility and became capable of flowering after developing ≈6 nodes. We recommend that marigold be propagated under daylengths ranging from 11 to 24-h or a 4-h NI and induced to flower under a 10 to 12-h finishing daylength. These daylengths produced high-quality cut flowers with thick stems and sufficient length. Finishing daylengths longer than 12 h substantially delayed time to harvest of marigold (Fig. 3). However, longer daylengths produced stems with considerably longer length, which may be desirable to florists. We considered marigold stems harvestable once they were greater than 26 inches (65 cm) in length with their terminal flower head 50% open.

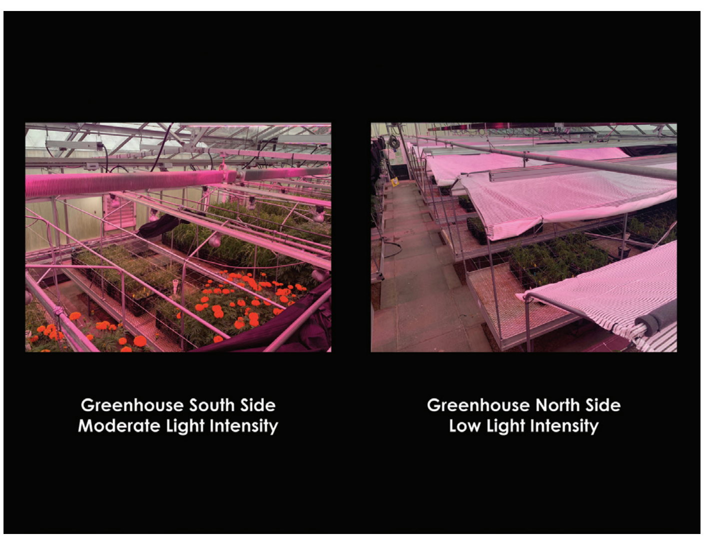

Fig. 3. Time to harvest of marigold 'Xochi' grown under 11-h daylengths during the seedling stage and finished under 10-, 11-, 12-, 13-, 14-, 15-, or 16-h daylengths or a 4-h night interruption (NI). Time to harvest was significantly delayed for plants grown under daylengths greater than 12 h, or a 4-h NI.

Furthermore, we found that witchgrass became capable of flowering after developing ≈4 nodes. We recommend that witchgrass be propagated under daylengths ranging from 13 to 24-h or a 4-h NI and finished under 13 to 16-h daylengths or a 4-h NI. Combinations of daylengths ensure that high-quality cut flowers with sufficient stem lengths are produced. Daylengths shorter than 13 h during finishing caused premature flowering and subsequent short stems for witchgrass (Fig. 4). We considered witchgrass stems harvestable once they were greater than 20 inches (50 cm) in length with a fully expanded panicle.

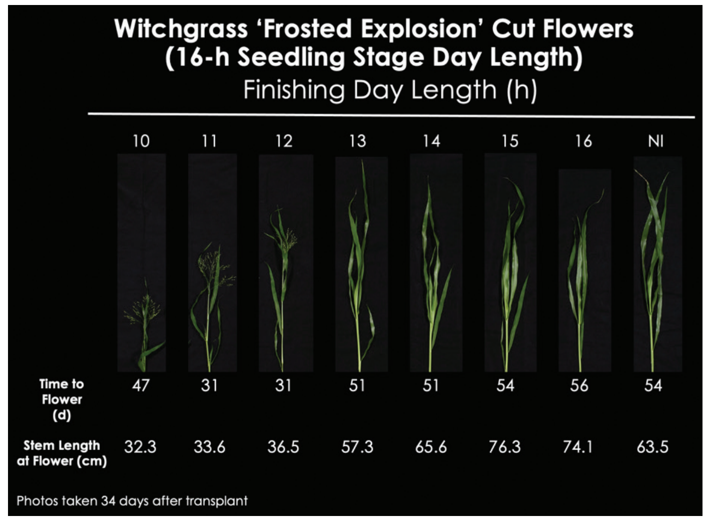

Fig. 4. Time to flower of witchgrass 'Frosted Explosion' grown under 16-h daylengths during the seedling stage and finished under 10-, 11-, 12-, 13-, 14-, 15-, or 16-h day lengths or a 4-h night interruption (NI). Cut flowers finished under daylengths from 13 to 16 h or a 4-h NI reached sufficient stem lengths for harvest, whereas those finished under day lengths of 10 to 12 h did not.

Additionally, both marigold and witchgrass should be grown under a moderate light intensity of 10 $mol\cdot m^{-2}\cdot d^{-1}$ at a minimum, as witchgrass did not produce harvestable stems when grown under low light intensities ≤5 $mol\cdot m^{-2}\cdot d^{-1}$.

Both dianthus 'Amazon Neon Cherry' and 'Amazon Rose Magic' initiated flower buds after developing ≈17 nodes. Dianthus 'Amazon Neon Cherry' and 'Amazon Rose Magic' seedlings can be grown under any daylength from 9 to 16-h, and finished under any daylength from 11 to 16-h or a 4-h NI from 10 PM to 2 AM. These daylengths all produced high-quality cut flowers with a similar time to harvest and harvestable stem lengths longer than 30 inches (75 cm). However, longer daylengths produced moderately longer stems. Both cultivars should be grown under a moderate to high light intensity of 10 to 15 $mol\cdot m^{-2}\cdot d^{-1}$ at a minimum to produce more harvestable stems, as low light intensities delayed time to flower and harvest, reduced yield, and produced thin stems with less attractive inflorescences (Fig. 5). We considered harvestable stems as those greater than 26 inches (65 cm) in length with the terminal inflorescence 50% open.

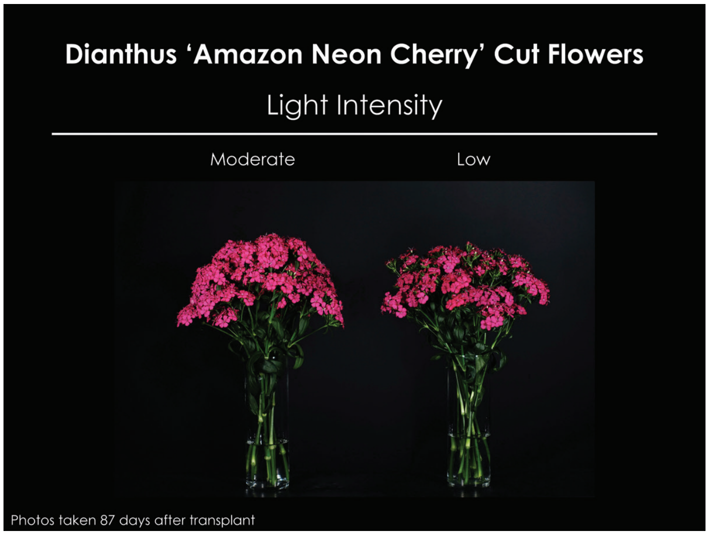

Fig. 5. Dianthus 'Amazon Neon Cherry' cut flowers grown under either a moderate or low light intensity during finishing. Low light intensities delayed time to flower and harvest, reduced yield, and produced lower-quality cut flowers.

In conclusion, our research demonstrates the importance of controlling daylength with low-intensity lighting and providing high-intensity supplemental lighting when growing specialty cut flowers in greenhouses when the daylength is short and natural light intensities are low, respectively. When properly utilized, low-intensity day-extension or NI lighting can prevent premature flowering and subsequent poor quality finished short-day plants, or induce flowering in long-day plants when desired. Additionally, low light intensities can reduce yield and decrease cut flower quality. A combination of moderate light intensities and proper daylengths allows growers to produce high-quality specialty cut flowers for local markets year-round.

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