Floriculture Research Alliance

Ready Research Results:
Daily Light Integral & Flowering Of Annuals

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by **MATTHEW BLANCHARD** and **ERIK RUNKLE**

DAILY light integral (DLI) refers to the cumulative amount of photosynthetic light that is received in one day. Determination of the DLI requires that light is measured repeatedly over time and then integrated. It cannot be determined instantaneously.

DLI is expressed as moles of photons of light received per square meter per day ($mol \cdot m^{-2} \cdot d^{-1}$), or moles per day. The DLI can be determined by some greenhouse environmental control systems or portable meters, such as the Greenhouse Weather Tracker from Spectrum Technologies. Alternatively, your greenhouse DLI can be estimated using DLI maps developed by Clemson University's Jim Faust that are available at **http://www.flor.hrt.msu.edu/assets/DLI-maps.jpg**.

Throughout the year, DLI inside a greenhouse can range from very low values (2 to 5 $mol \cdot m^{-2} \cdot d^{-1}$) to high values (25 to 30 $mol \cdot m^{-2} \cdot d^{-1}$) depending on the location, time of year, cloud cover and light transmission through the greenhouse. For the past several years at Michigan State University (MSU), we have experimented with more than 30 species and cultivars of common seed-propagated bedding plants to determine how various crops respond to DLI.

Experimental Methods

Seedlings were initially grown in 288-cell plug trays at 68°F (20°C) under a DLI of 10 $mol \cdot m^{-2} \cdot d^{-1}$ and a 16-hour photoperiod. Plants were then transplanted into 4-inch containers and grown in greenhouses at constant temperature set points ranging from 57 to 79°F, and under two DLIs with a 16-hour photoperiod.

The different DLIs were provided by sunlight, a combination of shade curtains and different supplemental lighting intensities from high-pressure sodium lamps. Experiments were performed twice to obtain average DLIs that ranged from 3 to 20 $mol \cdot m^{-2} \cdot d^{-1}$. Flowering data for each plant was recorded, and crop models were developed to quantify the influence of DLI on flowering time and plant quality.

Flowering Time

In all of the crops studied, time to flower decreased as DLI increased. For example, as DLI increased from 4.5 to 12 $mol \cdot m^{-2} \cdot d^{-1}$, time to flower in African marigold 'Moonstruck Orange' at 68°F decreased by one week (Figure 1). In some crops, the higher DLI accelerated flowering by developing fewer leaves before flower initiation. The acceleration of flowering under a high DLI can also be partially attributed to an

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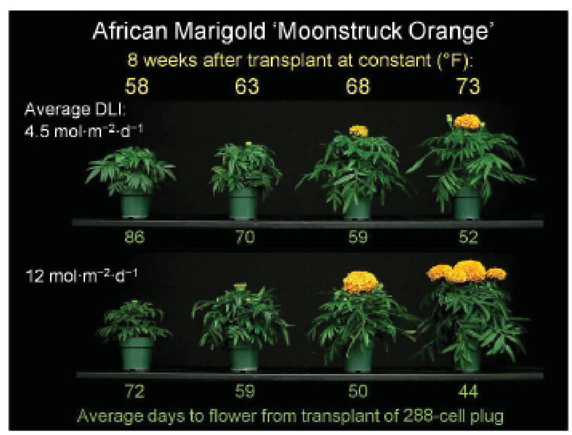

Figure 1. The effects of average daily temperature and daily light integral (DLI) on time to flower in African marigold 'Moonstruck Orange.' Plugs and plants were grown under a 16-hour photoperiod.

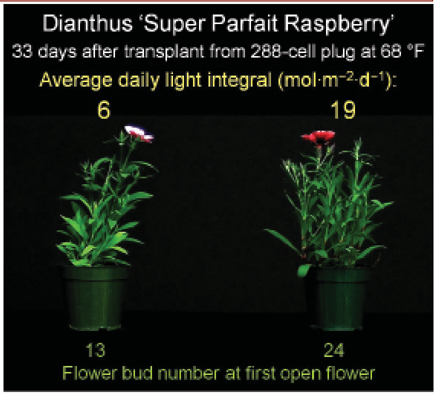

Figure 2. The effects of daily light integral on number of flower buds in dianthus 'Super Parfait Raspberry.' Plugs and plants were grown under a 16-hour photoperiod.

increase in plant temperature from higher light intensities.

For each species, we were able to estimate the DLI at which additional light did not shorten crop time. This "saturation DLI" for flower development varied among crops. For example, the estimated saturation DLI was less than 10 $mol \cdot m^{-2} \cdot d^{-1}$ for bedding impatiens and greater than 20 $mol \cdot m^{-2} \cdot d^{-1}$ for gazania. Thus, increasing the DLI from 10 to 14 $mol \cdot m^{-2} \cdot d^{-1}$ would accelerate flowering of gazania but not impatiens.

Increasing DLI follows the law of diminishing returns. As DLI continues to increase, it has less and less of an effect on flowering time (and to an extent, plant quality). For example, increasing the DLI from 4 to 8 $mol \cdot m^{-2} \cdot d^{-1}$ accelerates flowering much more than increasing the DLI from 8 to 12 $mol \cdot m^{-2} \cdot d^{-1}$. Therefore, the value of supplemental lighting is greatest under the most light-limiting conditions (such as in January in northern locations). The estimation of the saturation DLI for the most rapid flowering makes it possible to identify which crops benefit the most from supplemental photosynthetic lighting. In addition, we can use this information to determine which plants will be more negatively impacted by the presence of overhead hanging baskets.

Because most greenhouses don't have supplemental lighting in their entire operation, growers should prioritize lighting those crops with a high saturation DLI value (above 15 $mol \cdot m^{-2} \cdot d^{-1}$). Similarly, when light is limiting, hanging baskets should first be placed above crops with a low saturation DLI value, as they are generally more tolerant of lower light conditions.

Crop Quality

Plant quality of essentially all crops improved as DLI increased. For example, dianthus 'Super Parfait Raspberry' had a saturation DLI for flowering time of 10 $mol \cdot m^{-2} \cdot d^{-1}$; as DLI increased from 6 to 19 $mol \cdot m^{-2} \cdot d^{-1}$, time to flower at 68°F decreased by only three days, but flower number almost doubled (Figure 2).

Other crops, such as cosmos and zinnia, had more branches and thicker stems under a high versus low DLI. Therefore, the effects of DLI on crop quality should also be considered when determining which crops and when to light.

For more than 60 percent of the bedding plants we studied, crop time was not shortened as DLI increased above 15 $mol \cdot m^{-2} \cdot d^{-1}$. In most U.S. locations, the DLI inside a greenhouse (assuming at least 60 percent light transmission) is above the DLI saturation value for almost all of the bedding plants we studied by April. Therefore, the benefits of supplemental lighting during late spring are primarily to improve crop quality or extend the day length.

DLI is just one of several environmental factors that can influence the production of greenhouse crops. The impact of temperature and photoperiod on crop time and plant quality, and response variability among cultivars, should also be considered. **GG**

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