Responses To Temperature & Light

Longer growing time and cooler temperatures or shorter growing time with warmer temperatures? That's the question.

by ***MATTHEW BLANCHARD, ERIK RUNKLE*** *and* ***JONATHAN FRANTZ***

TEMPERATURE and light are the two environmental factors that primarily influence production time and quality of both young and finish plants. Knowledge of how crops respond to changes in temperature and light can help growers predict crop timing in a variety of greenhouse environments. One of the questions we've been addressing is whether less energy is consumed for heating when growing crops cool but for a longer period of time, compared to growing crops relatively warm but in a shorter period of time. To answer this question, we first need to quantify how plants develop in response to temperature and light. We can then estimate the growing conditions in which the least amount of energy is consumed on a per-crop basis.

Response To Light

The total amount of photosynthetic light (daily light integral or DLI) that a plant receives can also influence plant development and quality. DLI describes the cumulative amount of light that a plant receives in a 24-hour period and can be expressed as moles per square meter per day (mol·m–2·d–1). On cloudy days in winter, plants in a greenhouse in the northern third of the United States may only receive a DLI of 2 mol·m–2·d–1. In contrast, greenhouse crops may receive 25 to 30 mol·m–2·d–1 of light before whitewash or shade curtains are used in late spring. Seedling plugs develop better root systems when grown under at least a moderate DLI (>12 mol·m–2·d–1) compared to those grown under a lower DLI. Similarly, cuttings develop a better root system when the DLI in propagation is at least 5 mol·m–2·d–1. For this reason, most large plug and liner growers use supplemental photosynthetic lighting during the winter and early spring.

During the finish stage, some species flower faster when grown under a high DLI compared to a low DLI. These crops have a "quantitative irradiance response," a term coined by John Erwin at the University of Minnesota. For example, celosia 'Gloria Mix' grown at 64°F (18°C) and under an average DLI of 16 mol·m–2·d–1 flowered an average of eight days earlier than plants grown at the same temperature, but under 8 mol·m–2·d–1. Temperature and DLI can interact to influence crop timing and plant quality, and thus growers should consider both of these environmental factors to more precisely

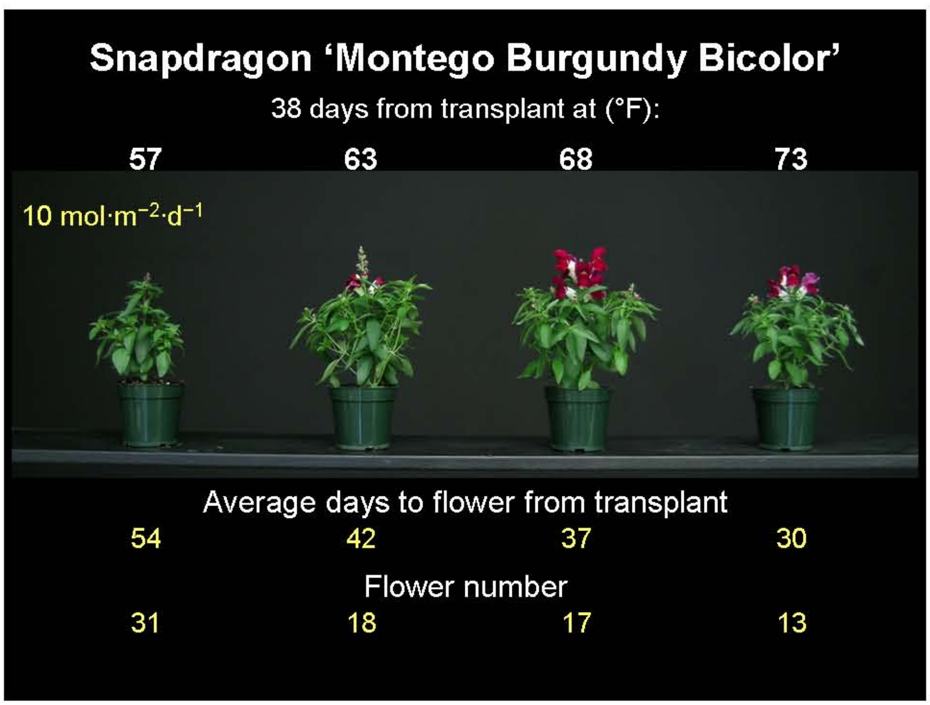


Figure 1. The effects of average daily temperature on time to flower and number of flower buds in snapdragon. Plants were grown under a 16-hour photoperiod and an average DLI of 10 mol·m–2·d–1. Photograph was taken 38 days after transplant from a 288-cell plug tray.

schedule crops.

At Michigan State University, we are currently performing experiments on numerous species of commercial bedding plants to generate species-specific information on how temperature and DLI influence plant development and crop timing. To date, we have studied about 20 species, and subsequent studies will include additional species to develop a large repository of data for grower support tools.

In each experiment, plants are grown in 288-cell plug trays in controlled temperature chambers at 68°F (20°C) under a 16-hour photoperiod and a DLI of 9 to 11 mol·m–2·d–1. When seedlings of each species are ready for transplant (three to four weeks after seed sow), they are transplanted into 4-inch pots and grown in greenhouses with four different temperature set points and two DLIs. "Cold tolerant" species such as pansy are grown at constant temperature set points of 57°F, 63°F, 68°F and 73°F (14°C, 17°C, 20°C and 23°C), while "cold-sensitive" crops such as vinca are grown at temperature set points of 63°F, 68°F, 73°F and 79°F (17°C, 20°C, 23°C and 26°C). At each temperature, plants are grown under a 16-hour photoperiod with two different DLIs provided by a combination of shade curtains and dif-

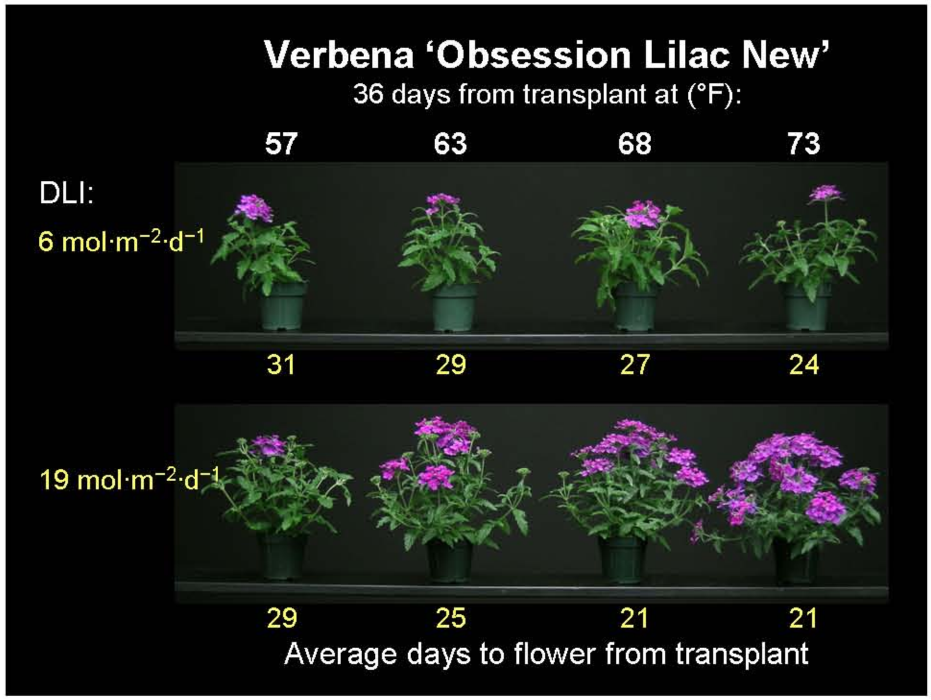


Figure 2. Effects of average daily temperature and daily light integral (DLI) on time to flower in verbena 'Obsession Lilac New.' Plants were grown under a 16-hour photoperiod. Photograph was taken 36 days after transplant from a 288-cell plug tray.

ferent light intensities from high-pressure sodium lamps. When each plant first flowers, the date, plant height, number of leaves and number of flowers and flower buds are recorded.

Flowering Time

In all of the bedding plants studied so far, time to flower from transplant decreased as air temperature increased. For example, snapdragon 'Montego Burgundy Bicolor' grown at 73°F flowered 24 days earlier than plants grown at 57°F under a similar DLI of 10 mol·m–2·d–1 (Figure 1). However, plants grown at 73°F had 18 fewer flower buds at first open flower than plants grown at 57°F. The increased flower number in snapdragon when grown cool is common for many other floriculture crops. Plants grown cool have a longer period of time to harvest light and thus perform more photosynthesis before flowering. The additional products of photosynthesis are used to develop additional flower buds, a more developed root system, more lateral branches and thicker stems.

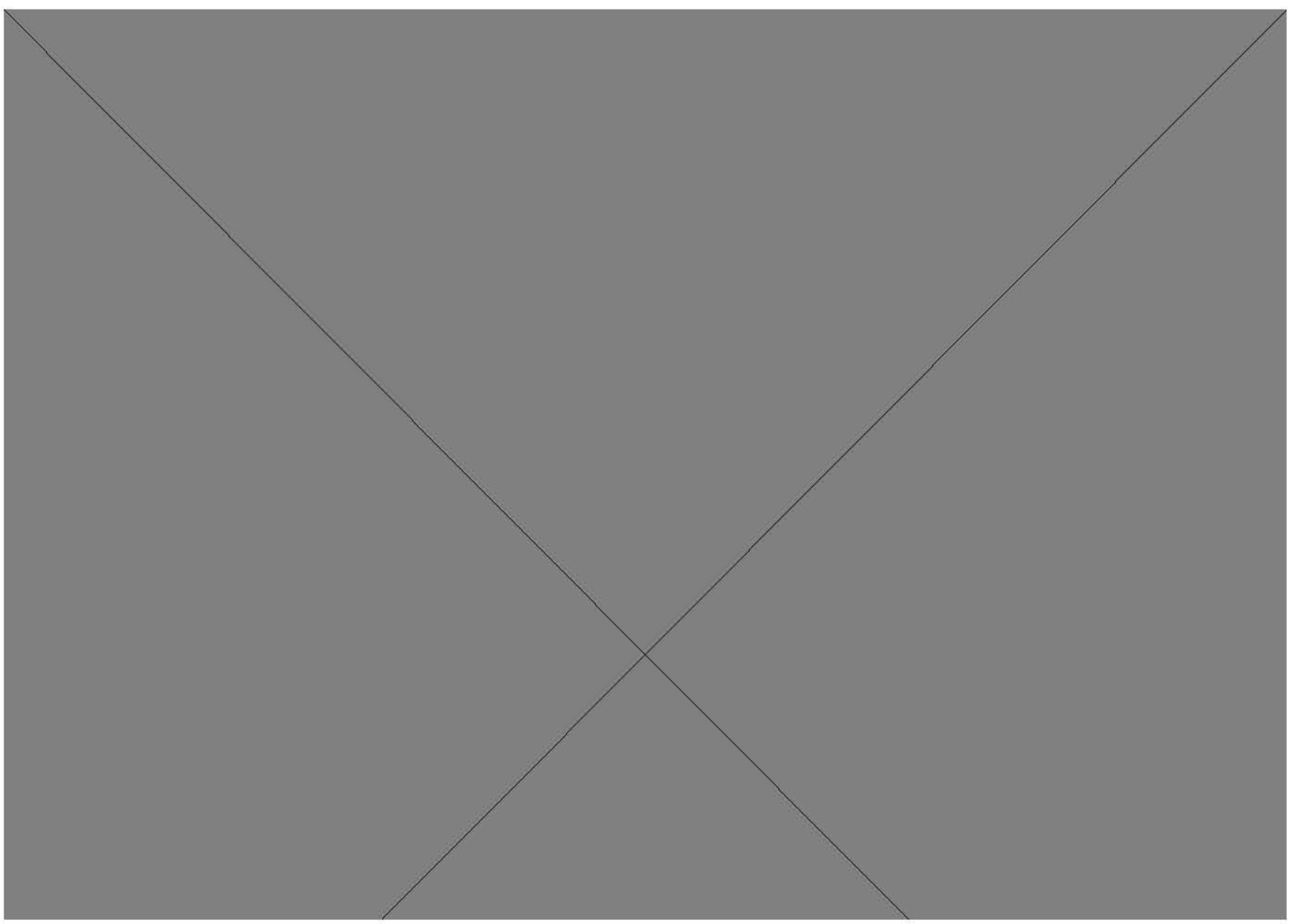
In some bedding plants, flowering time was also influenced by DLI. For example, verbena 'Obsession Lilac New' grown at 73°F flowered 6 days earlier under a high DLI (average of 19 mol·m–2·d–1) compared to a low DLI (6 mol·m–2·d–1) (Figure 2). One reason for the acceleration of flowering from a high DLI is that fewer leaves are formed before flower initiation, and thus plants flower earlier, compared with plants grown under a low DLI. The acceleration of flowering under a high DLI can also be partially attributed to an increase in plant temperature from higher irradiance levels.

Plant Quality

We are also collecting data on plant quality attributes because some crops may not be of acceptable quality (e.g., few flowers or branches) when grown at some temperature and DLI combinations. For example, cosmos 'Cosmic Orange' grown at 73°F and under a low DLI (6 mol·m–2·d–1) had 16 fewer flowers than plants grown at 63°F and under a higher DLI (18 mol·m–2·d–1). This information will be useful to growers when selecting growing temperatures to understand the trade-offs of shorter finishing times and decreased plant quality for some crops.

Estimating Energy Use

Another goal of our research is to identify the growing temperature that consumes the least amount of energy for each finish crop. Over the next year, our data on crop timing and plant quality will be integrated into Virtual Grower, which is a computer program created by Jonathan Frantz and colleagues of the USDA-ARS Greenhouse Production Group in Toledo, Ohio (Figure 3). This interactive decision-support tool will provide greenhouse growers with information on crop timing and the predicted energy consumption and cost based on greenhouse location and structure, heating set points, time of year, fuel type, fuel cost and other user inputs. When complete, we hope that Virtual Grower will help growers make pro-



duction and scheduling decisions and improve greenhouse energy efficiency. For more information or to download a free copy of Virtual Grower, visit: **www.ars.usda.gov/services/software/download.htm?softwareid=108**.

The most energy-efficient production temperature will not necessarily be the same for all greenhouse growers and will depend on plant species, location and finish date. For example, a bedding plant grower in Ohio may find it more economical to start production later in the spring and grow the crop at a warm temperature, whereas a grower in North Carolina may find it more cost effective to start production earlier and grow cool. Other factors will also need to be taken into consideration, such as the impact of growing temperature on the number of crop turns during the spring. For example, is it more economical to produce two turns of bedding plants at a cool temperature or

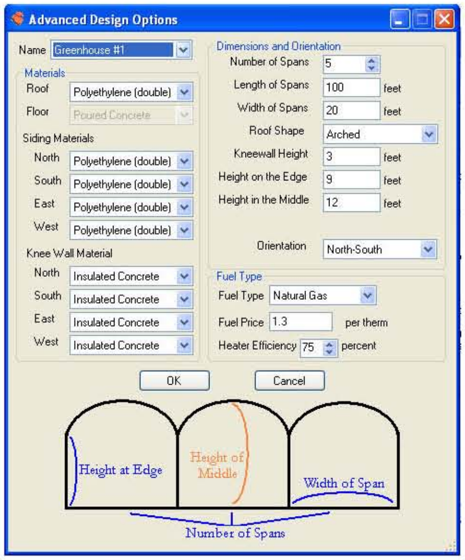


Figure 3. Users of Virtual Grower can input their own greenhouse characteristics, such as those shown here, to estimate their greenhouse fuel costs for heating.

three turns at a warmer temperature?

The identification of energy-efficient production temperatures for each species will also make it possible to group species with similar environmental responses and heating requirements. As our research continues, we look forward to sharing this information with the greenhouse industry so the production environment can be optimized and crops grown more energy efficiently. **GG**

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For a link to Virtual Grower software and John Erwin on which bedding plants will flower faster under a higher DLI, visit our Web site.