Special Research Report # 528: Production Technology

Improving the Energy Efficiency of Greenhouse Crop Production
2. Scheduling and Energy Consumption

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BACKGROUND

Volatile and increasing fuel prices have threatened the profitability of greenhouse businesses located in cold climates. In response, many growers have lowered their greenhouse temperature in an attempt to save fuel. However for some crops, this cool-growing strategy may have actually increased the amount of energy consumed per crop because production time was lengthened.

Species-specific data is needed on how temperature influences plant development and crop timing. This information can be used with greenhouse energy consumption models to identify the growing temperature that consumes the least amount of energy on a per-crop basis.

MATERIALS & METHODS

We quantified how temperature and daily light integral (DLI) influence plant development and quality on 33 species and cultivars of common seed-propagated bedding plants. See SRR # 527 for more information on experimental conditions.

Crop models generated from these experiments were used with the "Virtual Grower" software that is available free at www.virtualgrower.net to estimate the heating cost to produce each crop for different market dates and locations in the U.S.

RESULTS

We compared energy costs for growing a spring crop early and cool versus transplanting it later and growing warm. For example, the approximate production time of seed geranium (from transplant to flowering) at an average of 68 °F is 59 days (Fig. 1). If the crop was grown at 63 °F, the production time increased to 73 days. We estimated that to produce the crop for May 15 in Grand Rapids, MI, the heating cost would be 19% higher at 63 °F versus 68 °F (Table 1). Thus, it is more energy-efficient for growers in the north to start geranium production later and grow at a warmer temperature. The shorter production time could also lower other input costs and may allow other crops to be grown in that space, during the season when greenhouse space can be a limiting factor.

In contrast, to produce the same geranium crop in San Francisco, CA, heating costs would be 16% lower at 63 °F versus 68 °F on a per-crop basis. To produce the crop in Charlotte, NC, heating costs at 63 and 68 °F are similar.

The identification of energy-efficient production temperatures make it possible to group crops with similar environmental responses. For example, dahlia, French marigold, osteospermum,

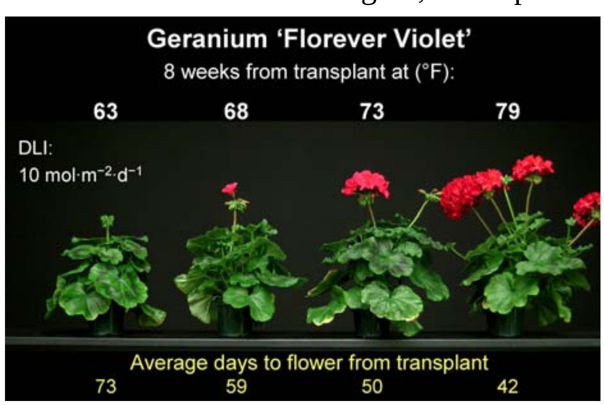

Figure 1. The effects of average daily temperature on time to flower of seed geranium 'Florever Violet'. Plants were grown under a 16-hour photoperiod and an average daily light integral (DLI) of 10 mol·m^{-2}·d^{-1}. Photograph was taken 8 weeks after transplant from a 288-cell plug tray.

Table 1. The estimated increase or decrease in heating costs by growing at constant 58, 63, 73, or 79 °F instead of constant 68 °F to first flowering on different finish dates and locations. Starting plant material assumes 288-cell plugs grown under long days and an average daily light integral (DLI) of 9 to 10 $mol \cdot m^{-2} \cdot d^{-1}$. Finish conditions assume long days and an average DLI of 10 $mol \cdot m^{-2} \cdot d^{-1}$. Calculations performed with Virtual Grower software with constant temperatures. – signifies not estimated.

Bedding plant	Location	1-Apr 58 °F	1-Apr 63 °F	1-Apr 73 °F	1-Apr 79 °F	15-May 58 °F	15-May 63 °F	15-May 73 °F	15-May 79 °F
African marigold Antigua series	San Francisco, CA	-13%	-4%	+33%	+29%	-25%	-10%	+10%	+25%
	Grand Rapids, MI	+31%	+11%	+14%	-11%	+24%	+24%	-16%	-14%
	Charlotte, NC	+19%	+13%	+26%	+3%	+7%	+7%	+21%	+29%
French marigold Janie series	San Francisco, CA	-36%	-9%	+9%	+36%	-44%	-22%	+11%	+22%
	Grand Rapids, MI	+4%	0%	+4%	+13%	0%	0%	+10%	+20%
	Charlotte, NC	-18%	-9%	+9%	+18%	0%	0%	+67%	+133%
Petunia Dreams series	San Francisco, CA	-33%	-17%	+8%	+25%	-33%	-11%	+11%	+22%
	Grand Rapids, MI	+29%	+8%	0%	+8%	+9%	0%	0%	0%
	Charlotte, NC	-17%	-8%	0%	+17%	-25%	0%	+25%	+75%
Petunia Wave series	San Francisco, CA	-22%	-11%	+11%	+17%	-21%	-14%	+14%	+21%
	Grand Rapids, MI	+45%	+13%	-8%	-13%	+40%	+5%	-5%	-5%
	Charlotte, NC	+37%	0%	+5%	+11%	0%	-11%	+11%	+22%
Seed geranium Florever series	San Francisco, CA	–	-13%	-10%	+10%	–	-16%	-8%	+8%
	Grand Rapids, MI	–	+18%	+10%	-6%	–	+19%	+5%	-3%
	Charlotte, NC	–	+20%	+9%	-3%	–	0%	-6%	+17%
Vinca Viper series	San Francisco, CA	–	0%	0%	-6%	–	0%	0%	0%
	Grand Rapids, MI	–	+73%	+21%	-9%	–	+47%	+18%	-12%
	Charlotte, NC	–	+39%	+6%	-6%	–	+13%	+13%	0%
Wax begonia Sprint series	San Francisco, CA	–	-17%	-6%	+11%	–	-27%	-13%	+7%
	Grand Rapids, MI	–	+20%	+6%	-3%	–	+6%	0%	-6%
	Charlotte, NC	–	-11%	-5%	0%	–	-22%	-11%	+11%

petunia Dreams series, snapdragon, and viola grown for the market date of May 15 in a greenhouse located in Grand Rapids would consume the least amount of energy per square foot per crop at 58 °F to 63 °F.

CONCLUSIONS

Crop timing data for these bedding plants can be used with “Virtual Grower” to predict greenhouse heating costs at different temperature set points. The most energy-efficient production temperature varied among crops, locations, and market dates. For early spring market dates in the northern U.S., greenhouse heating costs per crop were generally lower if grown at a warm temperature.

The cost of energy for heating is only one of many production expenses for greenhouse crops. Other factors, such as the number of crop rotations, overhead costs, and crop quality, must also be considered when selecting a growing temperature.

IMPACTS TO THE INDUSTRY

This information can assist bedding plant growers to produce greenhouse crops in the most efficient and cost-effective manner for their location, greenhouse characteristics, and desired market dates. We estimate that greenhouse energy inputs can be reduced up to 40% by using energy-efficient production temperatures. Therefore, information generated from this research could save floriculture growers substantial amounts of money by reducing their energy costs.

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For Additional Information

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or read the 12-article series on energy-efficient scheduling of bedding plants published from March 2009 to February 2010 in Greenhouse Grower magazine. These articles are available at www.flor.hrt.msu.edu/annuals.