Grower 101: Growing Plants Cooler, Part I

Weigh the pros and cons of lowering greenhouse temperatures and learn the effect it will have on crop quality, timing and pest and disease control.

By John Erwin, Charlie Rohwer and Ryan Warner

It is estimated that approximately 80 percent of the cost of heating a greenhouse is incurred at night. Given the long nights of winter in the North, heating is clearly a major cost in plant production. In addition, the dramatic increase in fuel prices in the last two years has drastically reduced profits for many greenhouse growers. Fuel costs this winter are forecasted to increase yet again compared to last year.

Because of increasing energy costs many growers are considering whether they should decrease greenhouse temperatures to reduce fuel costs. Lowering greenhouse temperatures reduces heating costs but will increase production times in most cases.

This is the first article in a two-part series that will weigh the pros and cons of lowering greenhouse temperatures and give an idea of the impact cooler temperatures will have on crop quality, timing and pest and disease control. Part I will discuss how temperature impacts seed germination, plant development rate and plant quality characteristics such as flowering and branching. Part II will address how reducing temperature affects insect and disease development and control and whether the increased production times will result in savings for growers. Ways to reduce heating costs by modifying the growing environment will also be discussed in Part II.

SEED GERMINATION

It is critical to provide appropriate temperatures during seed germination because seed germination and early seedling establishment are the most temperature-sensitive stages of plant development. Temperatures too warm or cool during seed germination will delay germination, reduce percent germination and decrease the uniformity in germination time. Temperatures cooler than 70º F can also promote "damping off" diseases, such as *Pythium spp.* For most species, germination media temperature should be between 72 and 76º F. After a crop is established most species will tolerate non-optimal temperatures more easily. For this reason do not try to save money by dropping temperatures during germination.

DEVELOPMENT RATE

Plant development rate (i.e., leaf unfolding rate) is dependent on the average daily temperature plants are grown at. Leaf unfolding rate increases as average daily temperature increases (see Figure 1, top right). However, above some maximum temperatures the leaf unfolding rate declines. Therefore, in general, plants will flower earlier when grown under warmer temperatures. Growing plants too hot will increase production time because the leaf unfolding rate is slowed.

We studied the effects of temperature on a number of major ➧

Figure 1. Leaf unfolding rate in response to temperature.

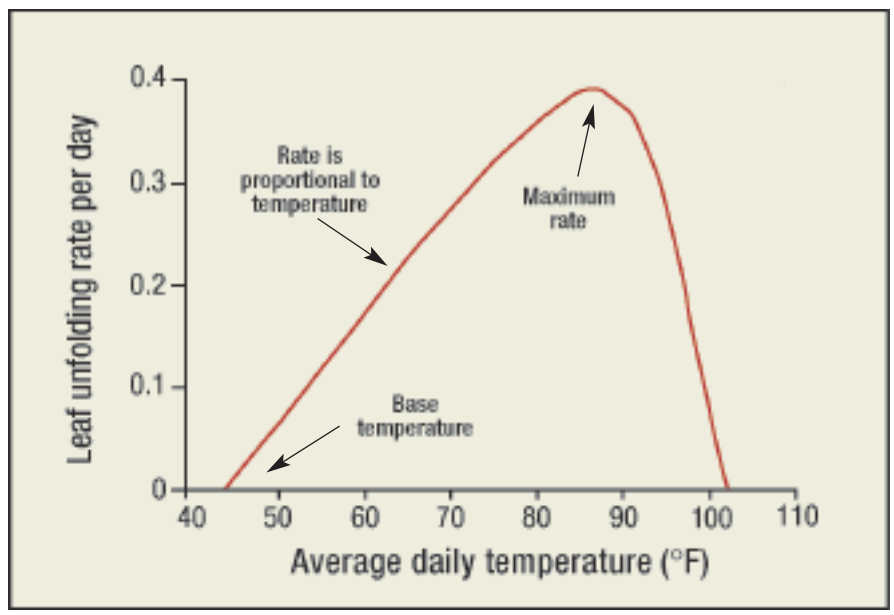

Figure 2. Effect of temperature on the number of days to flower for Impatiens wallerana *Hook f.,* Petunia x hybrida *Hort., and* Viola x wittrockiana *Gams. (pansy) cultivars. Plants were grown in growth chambers (to insure accurate temperature management) at reported temperatures from when the cotyledons expanded to when the first flower opened.*

Cultivar	54° F	61° F	68° F	75° F	Delay in flowering if 24-hour temperature is reduced 1º F (days)*
I. wallerana Super Elfin Lipstick	**	72	54	47	1.8
P. x hybrida Avalanche Pink	88	74	47	39	2.5
P. x hybrida Dreams Rose	84	67	46	37	2.3
P. x hybrida Purple Wave	112	88	57	45	3.3
V. x wittrockiana Colossus Yellow Blotch	95	82	63	58	1.9
V. x wittrockiana Crystal Bowl Supreme Yellow	72	63	51	46	1.3
V. x wittrockiana Delta Pure White	88	71	61	53	1.6
V. x wittrockiana Sorbet Blackberry Cream	68	60	50	45	1.1

**for temperatures between 54 and 75º F*
***plants died in this treatment*

bedding plant crops and showed that species time to flower is affected differently as temperature decreases. For instance, decreasing temperatures from 68 to 61° F increased days to flower for impatiens 'Super Elfin Lipstick' from 54 to 72 days, an 18-day increase. In contrast, decreasing temperatures from 68 to 61° F increased petunia 'Purple Wave' days to flower from 57 to 88 days, a 33-day increase. Each 1° F decrease in temperature will delay Purple Wave flowering by approximately three days. In contrast, each 1° F decrease in temperature only delays flowering of viola 'Sorbet Blackberry Cream' 1.1 days. Whether it would be cheaper to keep your temperature higher and decrease production time or lower temperature and increase production time is dependent, to a large extent, on the operating cost of your facility. But this research shows it also depends on what crops you grow. A general rule of thumb is that there is little benefit in increasing average daily temperatures above 72-74° F with any crop. With some species days to flower increases if temperatures are further increased.

Figure 3. Effect of day and night temperature on stem, leaf, flower and total shoot dry weight of 'Mimas' New Guinea impatiens. Data on the percent of total shoot dry weight are presented in parentheses. Plants were grown under a 9-hour photoperiod, and data was collected after 51 days in temperature treatments.

Night Temp. (°F)	Day Temperature (°F)			
	59	68	77	86
Total shoot dry weight (oz.)				
59	0.10	0.22	0.25	0.24
68	0.16	0.22	0.24	0.24
77	0.17	0.21	0.22	0.24
86	0.08	0.17	0.17	0.15
Stem dry weight (oz.)				
59	0.002 (2%)	0.036 (16%)	0.045 (18%)	0.050 (21%)
68	0.003 (1%)	0.030 (14%)	0.040 (17%)	0.050 (21%)
77	0.003 (1%)	0.029 (14%)	0.038 (17%)	0.046 (19%)
86	0.001 (2%)	0.025 (15%)	0.029 (17%)	0.029 (20%)
Leaf dry weight (oz.)				
59	0.09 (95%)	0.14 (62%)	0.16 (63%)	0.16 (66%)
68	0.10 (63%)	0.12 (52%)	0.15 (64%)	0.16 (66%)
77	0.12 (71%)	0.13 (63%)	0.15 (66%)	0.17 (72%)
86	0.08 (97%)	0.13 (77%)	0.13 (79%)	0.12 (79%)
Flower dry weight (oz.)				
59	0.0030 (3%)	0.049 (22%)	0.047 (19%)	0.031 (13%)
68	0.056 (35%)	0.075 (34%)	0.046 (19%)	0.031 (15%)
77	0.046 (28%)	0.047 (23%)	0.037 (17%)	0.0210 (9%)
86	0.0010 (1%)	0.0130 (8%)	0.0060 (4%)	0.0010 (1%)

FLOWERING

A positive impact of reducing temperatures is that flower size and number can increase. For example, decreasing temperatures from 76 to 59° F increases flower diameter of chrysanthemum 'Bright Golden Anne'. Similarly, decreasing temperatures from 77 to 59° F increases fuchsia 'Dollar Princess' flower width from about 2 to 3 inches. Comparable increases in flower size as temperature decreases are observed for many other crops.

Flower number per inflorescence or node usually increases as temperature drops to a point. For instance, zonal geranium 'Veronica' increased from 15 to 50 flowers per inflorescence as temperature decreased from 85 to 54° F. Decreasing temperature from 77° F to 59° F increased Dollar Princess flower number per node from three to six flowers. For the most part, plants have an optimal temperature for maximum flower number. For instance, Thanksgiving cactus' flower number per node is greatest when day and night temperatures are 68° F, i.e., increasing or decreasing temperatures from 68° F decreases flower number per node. Decreasing temperatures below 59° F will decrease fuchsia flower number per node.

BRANCHING

Another potential positive aspect of reducing greenhouse temperature is increased plant quality due to increased branch-

ing. As we saw with Dollar Princes, decreasing greenhouse temperatures from 72 to 55º F increased lateral branch number at flowering from 6 to 12 branches. Increases in branch number as day and night temperature decrease is observed in other species as well.

PLANT HEIGHT

As mentioned previously, most heating costs are incurred at night, making most growers focus on reducing night temperatures. Reducing night temperatures while maintaining the same day temperatures will increase stem elongation through increasing the difference between day and night temperatures. The greater the difference (DIF) between day and night temperatures, the more stem elongation or stretch you will see. Just reducing night temperatures will most likely increase stem elongation, resulting in crops that may require more growth regulator applications or applications at higher concentrations. Alternatively, using a morning temperature dip can help to reduce the necessity for growth regulators. Plants are stretching the most at the end of the night and early in the morning. Reducing temperatures 30-60 minutes before dawn and maintaining a lower temperature for the first few hours of the day will reduce the amount of plant growth regulators needed on a crop, a practice called morning temperature dip or drop.

DRY WEIGHT

Whole plant mass or weight is affected by day and night temperatures differently. In general, as day temperature increases up to 76-80º F plant weight at flowering usually increases. In contrast, as night temperature decreases plant weight usually increases. New Guinea impatiens above media weight was greatest when plants were grown with a 77º F day and 59º F night temperature (Figure 3, left). As temperatures increased or decreased from these temperatures, plant weight at flower decreased.

Whether a plant has bigger stems, flowers or leaves it is affected by day and night temperatures. As day temperatures increase and night temperatures decrease the proportion of photosynthates, weight that goes to the stem, increases. Dropping day and night temperatures from 77 to 59º F or increasing temperatures to 86º F almost eliminated flowering on New Guinea impatiens. Flower dry weight of New Guinea impatiens 'Mimas' was greatest when plants were grown at a constant 68º F. If either day or night temperature deviated from 68º F floral dry weight decreased (Figure 3, left), which appears to be the case with many other cultivars.

WHAT NOT TO GROW COOL

Not all bedding plant crops will adapt well to a cool temperature regime, since many bedding plants are from tropical climates. One example is vinca, indigenous to Madagascar, which will not tolerate temperatures below 68º F. Celosia, cleome, cosmos, gomphrena, melampodium, portulaca and sunflowers are examples of other crops that will not tolerate being grown cold (temperatures less than 65-68º F) without having growth severely reduced. To deal with this problem two options are available: 1) don't grow these crops or 2) group these crops together, and maintain a section of your greenhouse warmer than the rest, use heat mats under the crops or skirt benches with under-bench heaters to increase temperatures.

In contrast to warm temperature-loving crops, several bedding plant crops will perform well under cool temperatures, including snapdragon, alyssum, dianthus and pansies. For these crops quality will not be compromised under cool conditions, but crop production time will still be longer than under warmer conditions. GPN

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