A SHORT HISTORY OF DIF:

USING TEMPERATURE TO CONTROL PLANT HEIGHT

by ROYAL HEINS and JOHN ERWIN

Using DIF (the difference between day and night temperature) all day and dropping the day temperature for 2 hours beginning immediately at sunrise has become a common practice of growers who want to control plant height.

The concept of using cooler day temperatures than night temperatures for height control originated with research by Dr. Meriam Karlsson, now a faculty member at the University of Alaska. In 1984, Karlsson was a graduate student at Michigan State University (MSU); in her research she observed that chrysanthemum height at flowering became progressively shorter as the plants were grown with progressively cooler day temperatures.

Dr. Royal Heins discussed this observation with Andy Mast, a grower in Grand Rapids, MI. Mast asked if day temperature affected Easter lilies in the same way. Since Heins did not know, Mast donated some Easter lily bulbs in 1985 and Heins, along with Dr. John Erwin, then a graduate student, grew them under six different day and night temperature treatment combinations. Plants became progressively shorter as day temperature decreased — the second key obser-

INTERESTED IN APPLYING DIF?

Most growers who have tried DIF believe it is a valuable production tool that you can use to control plant height. If you're considering trying DIF, here are a few suggestions.

- Try DIF with a small number of plants on a limited basis within one zone or greenhouse rather than an entire range.
- Start with a zero DIF. If it doesn't provide adequate height control, implement a negative DIF in 1° increments. Plant response is greater when you go from a positive DIF to a zero DIF than when you go from a zero DIF to a negative DIF. A commitment to trying to keep the day temperature cooler will go a long way toward controlling plant height.
- Because warm air rises, plants grown toward the top of a greenhouse may not receive the same DIF as plants grown on the benches below. Fans, such as circulating or horizontal air flow, can be used to maintain an even temperature throughout the greenhouse.
- When trying to drop the temperature in the morning, be aware that different heating systems retain heat for varying lengths of time. Hot water and steam pipe systems will hold the heat longer than unit heaters. Overhead systems dissipate heat faster than in-floor systems.
- You don't need an environmental computer to use DIF, but you must make the commitment to monitor the greenhouse temperatures closely day and night. This is why it is best to start out using DIF in just a small area.
- If you run into problems with DIF, remember you can always go back to your old production methods, including using growth retardants.

vation on the way to understanding the effects of day and night temperature on plant stem elongation.

Testing The Lower Daytime Temperature Theory

The third key observation — and probably the most important — was made by Erwin. During the 1986 season, Heins decided to grow another lily crop under six different day and night temperature combinations. Erwin decided to conduct a similar experiment after reading a paper on plants that were exposed to a factorial set of day and night temperature combinations by being moved among several different greenhouse sections.

Lily plants were moved twice a day — at 8 a.m. and 5 p.m. — among five greenhouse sections set at 14°C (57°F), 18°C (64°F), 22°C (72°F), 26°C (79°F), and 30°C (86°F). This experimental procedure increased the number of day and night temperature treatments from six to 25. It was obvious throughout the experiment that plants were shorter as day temperature decreased.

The Key To DIF

As plants flowered, those from each treatment were placed in a cooler so Erwin could photograph them — a move that proved to be key in the discovery of DIF. To Erwin's amazement, plants grown with similar day and night temperatures were the same height.

The concept of DIF had just been discovered.

The DIF concept was trialed by several growers the following year. One day, Heins visited a grower who said he was using the negative DIF treatment on his Easter lilies with little effect, even though he was growing his crop with a cooler day than night temperature. When asked when and how he was lowering temperatures, he said he opened his thermal blanket slowly in the morning so the temperature did not drop too abruptly.

A Quick Dip

Because the MSU experiments had been conducted with abrupt temperature changes, Heins suggested the grower completely open his thermal blanket at sunrise so the temperature *would* drop abruptly. The grower was very hesitant to do this because at the time growers thought such a quick temperature dip was somehow "bad" for the plants.

However, he did open the blankets abruptly the next morning, and within 2 days he saw a significant change in plant appearance and elongation. The fourth key observation was now in place — a negative DIF was more effective in reducing stem elongation when the temperature was abruptly dropped at first light than when the temperature was dropped slowly or later in the morning.

Easter Lilies Reveal Another Discovery

The next step in the development of the temperature-dip technique came from a problem Andy Mast faced with his Easter lily crop that same year (1987). He wanted to control height with DIF but needed to maintain a high average daily temperature to achieve an adequate development rate.

While maintaining a lower day than night temperature would control height, it would reduce the average daily temperature and therefore slow plant development. Night temperature could be raised to offset the cool day temperature, but night temperatures above 70°F are not recommended on Easter lilies because of problems with flower bud abortion, root rot, and lower leaf yellowing.

Mast already maintained a 70°F night temperature. He called Heins to ask if he could drop the greenhouse temperature abruptly at sunrise, maintain the low temperature for a couple of hours, then raise the temperature the rest of the day to 70°F to achieve an average daily temperature near 70°F.

The concept seemed logical, so Mast tried it while MSU conducted a controlled experiment to test the idea. Mast was very satisfied with the results.

The MSU Treatments

In MSU experiments, Heins and Erwin placed plants into one of seven treatments and moved them among greenhouses during the day for a number of treatment combinations. Black cloth was pulled during the night (5 p.m. to 8 a.m.) to ensure a constant night span.

The experiments confirmed earlier observations which showed plant shoot elongation was progressively reduced as DIF became more negative. A dip in temperature at first light also reduced stem elongation.

Clearly, Mast's idea worked. A dip in temperature at sunrise followed by a warmer temperature the rest of the day could be used on Easter lilies to reduce stem elongation while maintaining adequate development.

While the first 2 hours of daylight were more important than the remaining hours, the shortest plants were those exposed to a negative DIF condition all day, not just the first 2 hours following sunrise.

DIF: Now A Common Practice

Even though it was once considered heresy, the use of lower day temperatures is now common in the greenhouse industry. The 2- to 3-hour temperature dip beginning at sunrise has especially gained wide acceptance for two reasons:

- Significant height reduction can occur without greatly affecting flowering rate.
- The temperature dip can be used for height control in most climates since the coolest time of the day is normally at sunrise. Some reduction in height can be achieved even if temperatures later in the day are greater than the night temperature. **GG**

About the authors: Dr. Royal Heins is professor and Dr. John Erwin was graduate student at the time this research was conducted, Department of Horticulture, Michigan State University, East Lansing, MI 48824. Erwin is currently assistant professor, Department of Horticulture, University of Minnesota, St. Paul, MN 55108.