Take Your Plants' Temperature

Knowing shoot-tip temperature can improve growers' control of greenhouse crops.

by JAMES E. FAUST AND ROYAL D. HEINS

MANIPULATING greenhouse air temperatures helps growers control plant development, or crop timing; but knowing plants' shoot-tip temperature can allow more accurate control. In the shoot tip, or meristem, cells are constantly dividing and differentiating into leaves or flowers. It is the meristem temperature that controls the rate at which leaf unfolding and flower development occur.

The obvious limitation for growers is that greenhouse climate-control systems control air, not plant, temperature.

How much, then, does shoot-tip temperature actually differ from air temperature? Several experiments at Michigan State University over the past few years may answer this question.

Shoot-tip temperatures are influenced by several factors besides air temperature – transpiration, solar radiation, long-wave radiation, humidity, and air velocity. We inserted fine-wire thermocouples into the shoot tips of vinca bedding plants to determine how greenhouse environment affects shoot-tip temperature during night and day.

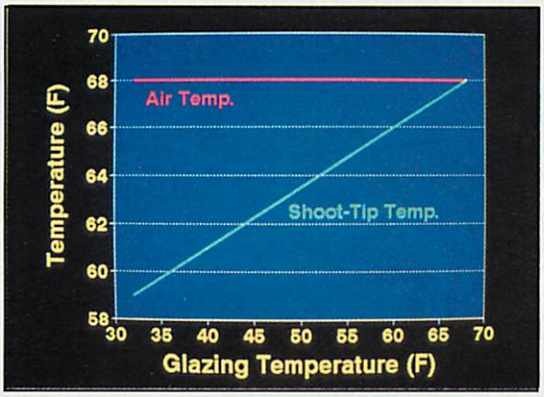

Figure 1. Shoot-tip temperatures decrease as glazing material temperature decreases.

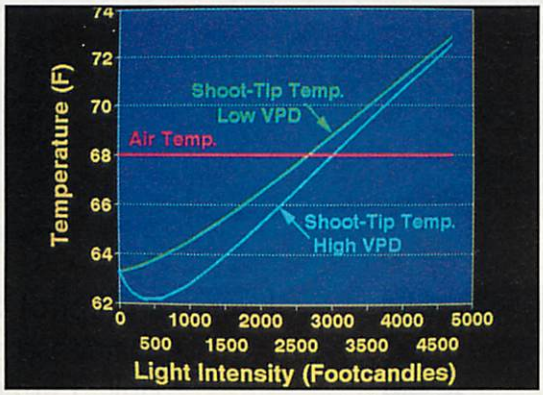

Figure 2. At low vapor pressure deficits (VPDs), shoot-tip temperatures increase as more solar radiation is absorbed. At high VPDs, shoot-tip temperatures may decrease early in the morning.

Night Temperatures

At night, long-wave radiation is the primary mode of energy transfer between plants and other solid objects (such as benches, glazing material, etc.), regardless of air temperature and the distance separating the objects. In the greenhouse, the plant is continually emitting radiation to the surrounding environment. Likewise, the surrounding greenhouse structure is continually emitting long-wave radiation to the plants. The amount of energy emitted is a function of an object's temperature – the warmer the object, the more energy emitted.

Practically speaking, in the greenhouse at night, plants are warmer than the structure because the glazing material is directly exposed to the outside environment. So there is a net loss of energy from the relatively warm plants to the relatively cold glazing material. The greater the temperature difference between plant and glazing, the larger the net loss of energy from the plant.

Figure 1 indicates the effect of glazing material temperature on shoot-tip temperature in a greenhouse maintained at a constant 68°F. Shoot-tip temperature decreased as glazing material temperature decreased. When glazing material temperature reached 32°F, shoot-tip temperature was 59°F, 9°F below air temperature.

Plant temperatures at night are always at or below surrounding air temperature. The exception is when infrared heaters are used – here plant temperature can be warmer than surrounding air. Thermal blankets can also help: Since the blankets block plants' exposure to the cold glazing material, the plant "sees" a warmer sky – the blanket – and is therefore warmer.

Day Temperatures

During the day, the situation is more complex. In addition to long-wave radiation exchange, solar radiation (sometimes called short-wave radiation), and vapor pressure deficit (VPD) influence plant temperatures.

Sunlight provides energy plants use for photosynthesis. However, less than 2% of the energy a plant absorbs is used for photosynthesis. Most instead is dissipated as heat, resulting in warmer shoot-tip temperatures.

At relatively low vapor pressure deficits (VPD), transpirational cooling of plant tissue is limited; therefore, shoot-tip temperature increases as the amount of solar radiation absorbed increases (Figure 2). But shoot-tip temperatures under high VPD conditions

may actually decrease early in the morning. This occurs when the stomata open at sunrise and solar radiation is relatively low, so the amount of energy lost due to transpiration exceeds the amount of energy absorbed from sunlight. This phenomenon only occurs when VPD is high and solar radiation is low.

Figure 3 shows shoot-tip temperature changes over the course of a sunny and a cloudy day when the greenhouse air temperature was kept at 68°F. At night, shoot-tip temperature was 4.5°F below air temperature. During a cloudy day, shoot-tip temperature stayed below air temperature. On a sunny day, shoot-tip temperature exceeded air temperature from 9 a.m.-3 p.m.

We have observed shoot-tip temperatures as much as 10°F warmer than the air under high light conditions, indicating why shading is so important under high light conditions.

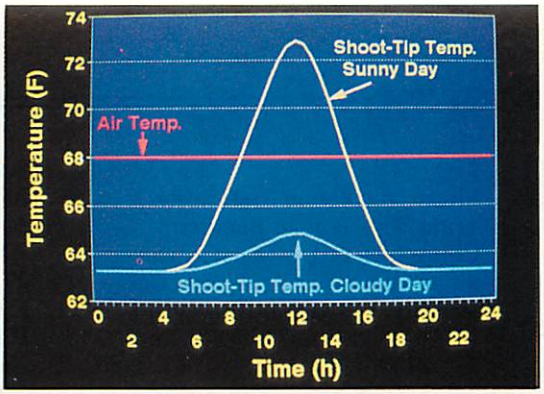

Figure 3. On a cloudy day, this house's shoot-tip temperatures remained below air temperature. On a sunny day, shoot-tip temperatures exceeded air temperatures from 9 a.m.-3 p.m.

Air Velocity

When air velocity is low, large temperature gradients can occur inside the greenhouse, which can result in hot or cold pockets of air surrounding the plant canopy. Well-circulated air provides a more uniform temperature environment inside the greenhouse, resulting in plant temperatures closer to that of surrounding air. Horizontal air-flow fans create the air movement necessary to reduce the differences between plant and air temperature.

Climate Control

Measuring shoot-tip temperature in a commercial greenhouse is impractical, but predicting shoot-tip temperatures is possible via mathematical models that use environmental measurements such as solar radiation, air temperature, VPD, air velocity, and glazing material temperature to make a prediction of shoot-tip temperature.

Figures 1-3 show predicted shoot-tip temperatures based upon thousands of actual measurements. The climate control computer can use the predicted plant temperature information to help a grower control the greenhouse environment and time the crop.

We expect that future climate-control computers will incorporate plant temperature models and decision-support tools to improve a grower's ability to meet market dates and buyer specifications. **GG**

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Greenhouse Gatherings

MAY

21-June 1
Expo Garden Tours, "Gardens of England & Chelsea." Contact Expo Garden Tours, 145 Fourth Ave., Suite 4A, New York, NY 10003, 212-677-6704, fax 212-260-6913.

25
California Ornamental Research Federation's (CORF) 13th Annual Educational Seminar Series, Watsonville-Salinas, CA. Contact CORF, 2167 Reineman Rd., Fallbrook, CA 92028, 619-723-9910, fax 619-723-0148.

JUNE

21
South Jersey Flower Growers Association's Annual Trade Show and Core Seminars and Exhibit, Dutch Inn, Gibbstown, NJ. Contact Beverly Fineran, 201 S. Odessa Ave., Galloway, NJ 08215, 609-965-6675.

21
Floral Marketing Association's Train-The-Trainer Seminar, Columbus, OH. Contact Produce Marketing Association, 1500 Casho Mill Rd., P.O. Box 6036, Newark, DE 19714-6036, 302-738-7100, fax 302-731-2409.

22-24
Washington Floricultural Association's (WFA) Annual Meeting, Doubletree Suites, Seattle, WA. Contact WFA, 3129 179th Ave. E, Sumner, WA 98390, 206-862-5213.

22-24
Professional Plant Growers Association (PPGA) Board Meetings, San Jose, CA. Contact PPGA, P.O. Box 27517, Lansing, MI 48909, 800-647-PPGA or 517-694-7700, fax 517-694-8560.

25-27
Tenth Annual Seeley Conference, Cornell University, Ithaca, NY. Contact Robert W. Langhans, 20 Plant Science Bldg., Cornell University, Ithaca, NY 14853-5908, 607-255-5113, fax 607-255-9998.

27
E.C. Geiger, Inc.'s 1995 Field Day, Harleysville, PA. Contact Janet Haberle, E.C. Geiger, Inc., P.O. Box 230, Mainland, PA 19451-0230, 215-256-4777, fax 215-256-7948.

27-30
American Horticultural Society's (AHS) National Symposium, Pasadena, CA. Contact AHS, 7931 E. Boulevard Dr., Alexandria, VA 22308-1300, 800-777-7931, fax 703-765-6032.

29-July 2
Florida Nurserymen and Growers Association's (FNGA) Annual Meeting, Disney's Contemporary Resort, Lake Buena Vista, FL. Contact FNGA, 5401 Kirkman Rd., Suite 650, Orlando, FL 32819-7991, 407-345-8137.

JULY

8-12
Ohio International Floral Short Course, Cincinnati Convention Center, Cincinnati, OH. Contact Ohio Florists' Association, 2130 Stella Court, Suite 200, Columbus, OH 43215-1033, 614-487-1117, fax 614-487-1216.

25-27
Penn Allied Nursery Trade Show, Fort Washington Expo Center, Fort Washington, PA. Contact Pennsylvania Nurserymen's Association, 1924 N. Second St., Harrisburg, PA 17102, 800-898-3411, fax 717-238-1675.

30-August 2
American Society for Horticultural Science (ASHS) Annual Meeting, Montreal, PQ, Canada. Contact ASHS, 113 S. West St., Suite 400, Alexandria, VA 22314, 703-836-4606.

30-August 5
Perennial Plant Association's (PPA) Annual Meeting, Radisson South Hotel, Minneapolis, MN. Contact PPA, 3383 Schirtzinger Rd., Hilliard, OH 43026, 614-771-8431.