Plant Temperature Under Greenhouse Curtains

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Temperature is the primary factor that controls the speed of developmental processes in plants, such as time to flower, root development, and leaf unfolding. Growers usually monitor and control the temperature of the air because it's easy and straightforward to do. Of course, it's the temperature of the plant, not the surrounding air, that controls plant development. Specifically, the temperature of shoot tips and root tips regulates how fast new tissues form.

Air temperature usually has the largest effect on shoot-tip temperature, but other factors moderate that effect, including light intensity, humidity, air velocity, method of heating (e.g., bottom heating or infrared heating), plant water status and water temperature. The temperature of the ceiling above a plant, whether it is the open sky, a greenhouse glazing material or an energy curtain, can also influence plant temperature, especially at night.

Plants gain or lose energy through three processes: radiation, conduction, and convection. Some simplified definitions and examples of each are in Table 1. At night, energy can be radiated from a warm plant to a cold ceiling, which decreases plant temperature. The magnitude and rate of this energy loss depends on how cold the glazing material is, as well as other factors such as humidity and the characteristics of the plants and the ceiling.

A few years ago, we conducted a detailed experiment to quantify how different greenhouse curtains influenced shoot-tip temperature of New Guinea impatiens at night. The experiment was performed in glass-glazed greenhouses during winter, when outdoor temperatures were near or below freezing. Different curtain materials were pulled closed at night, the air temperature was maintained at 68° F, and the effects of humidity and the curtain materials on plant temperature were quantified.

Table 1. Energy transfer processes, their simple definitions, and examples.

Heat transfer process	Simple definition	Example
Radiation	Heat transfer from one surface in the line of sight of another surface	Heat from the sun, which we don't feel under shade
Conduction	Heat transfer through a material, from the hotter side to the cooler side	Energy moves from a heated end of a metal pipe to the unheated end
Convection	Heat transfer by the movement of air, water, or some other fluid	The fan of a unit heater blows air across flames, distributing the heat

Briefly, here's what we learned. These results are consistent with similar research reports with other crops.

On a cold night, plants under a curtain were warmer than those without a curtain. The shoot-tip temperature of New Guinea impatiens at night was up to 4.1° F warmer when under a curtain even though air temperature was the same. Thus, plants lost more energy to the colder greenhouse glazing material compared to plants under the warmer curtain. All curtain materials studied increased plant temperature. However, shoot-tip temperature was warmer under blackout curtains with closed-weave construction compared to shading curtains with open weave construction.

The effect of the curtain was greater on colder nights. The effect of the curtains on plant temperature was determined when the outdoor night temperature was either mild (31° F) or cold (13° F). On the mild night, the glazing material surface was 62° F, while the glazing was 6 °F lower on the cold night. The temperature of an aluminized energy curtain above plants was warmer in both cases, 67° F on the mild night and 65° F on the cold night. As a consequence, the shoot-tip temperature of New Guinea impatiens was 2.9° F warmer under the curtain than under the glazing on the cold night, and 1.8° F higher under the curtain on the mild night.

The difference in plant temperature and air temperature was greater at a low humidity. Plants in a greenhouse with a high relative humidity (60 to 80 percent) were an average of 1.8° F warmer at night than plants in a greenhouse with a low humidity (25 to 40 percent) as a result of reduced transpiration. The decrease in shoot-tip temperature at night is also influenced by air flow around plants. The use of horizontal air flow fans reduces the difference between air and plant temperature, which emphasizes the benefits of air movement at night.

These results highlight an often overlooked benefit of retractable energy curtains. Not only do they save energy costs by serving as an insulative layer and reducing the amount of space heated, plants under the curtains can be at least a few degrees warmer than plants not under a curtain. Consequently, plant development under a curtain will be slightly faster, especially when the nights are cold and the humidity is low. g

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