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77. Reducing temperatures with shading. Parbst, K. Greenhouse Management 31(4):57-59. 2011.

Reducing temperatures with SHADING

Shading can be a useful tool for controlling greenhouse temperatures

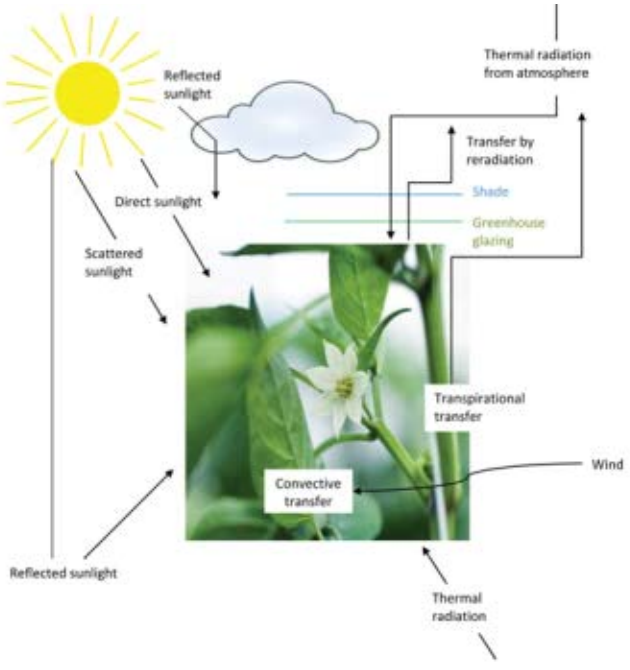
Plants, like humans, thrive when environmental conditions remain within comfortable ranges and extremes are avoided. The temperature extremes of the past summer and this winter have provided a good test for the designs of greenhouse ventilation/cooling and heating systems.

Last summer some greenhouse growers would have appreciated the ability to decrease the peak daytime temperature by a few degrees. The benefits of lowering temperatures include greater worker productivity and/or better plant quality by avoiding heat stress and increased water use efficiency. Also, retail growers may be able to lengthen customer visits by lowering temperatures and providing a more comfortable shopping experience.

Focus on leaf temperature

Efficient application of shading can be a useful component of effective ventilation/cooling as well as an irrigation management strategy. Although a single sensor in a greenhouse heating/cooling zone is often used to provide environmental control equipment with decision-making data, the best objective is to maintain the leaf temperature in the most productive range.

Leaf temperature is an indicator of the level of energy present in a leaf as a result of an energy balance between the energy entering and exiting the leaf. Solar



Energy is lost from a plant through emitted infrared radiation, convection, conduction and heat loss via water evaporation.

photo courtesy of Urban Gardener

Key Points

1. Efficient application of shading can be a useful component of effective ventilation/cooling as well as an irrigation management strategy.

2. Outdoor black shade cloth placed over a greenhouse becomes a heat radiator, decreasing its effectiveness as a net radiation reducer within the greenhouse.

3. When using fixed shade material as a means to reduce radiation, it is beneficial to select materials that are reflective and lower greenhouse temperatures.

radiation and infrared radiation from the surroundings (i.e., structure, glazing, floor, etc.) act to increase the leaf energy. Energy is lost, or the leaf is cooled, via emitted infrared radiation, convection, conduction and heat loss via water evaporation.

Air temperature, which influences the plant, is not a direct indication of leaf temperature. Outdoors on sunny, summer days, the upper leaf temperatures are often significantly higher than the air temperature. Depending on the plant and leaf location, the leaf temperature can be 10°F-30°F higher than the air temperature. When clouds obscure the sun, leaf temperatures can drop to within a few degrees of the air temperature. The temperature of shaded leaves on the same plant can actually be a few degrees below air temperature.

Reducing greenhouse temperatures

Greenhouse shading can be used to alter several forms of radiant energy. Shading can be used to reduce the amount of incoming

Research has found that there is little to no reduction in the greenhouse temperature from installing black shade cloth over the structure.

For externally-mounted shade cloth, a 60 percent reflective shade material was found to reduce the greenhouse heat gain by approximately 30 percent.

solar radiation as well as alter the exchange of infrared radiation between the leaf and its surroundings. Growers must decide which shade materials to use and when to use them.

Plants and plant leaves exhibit a large variability in susceptibility to heat damage. The resistance of a plant or leaf to damage by heat is time dependent. The longer a plant is exposed to potentially damaging temperatures, the greater the temperature effect on plant tissue viability.

Shading can reduce leaf temperatures and prevent heat damage. Shading can also reduce photosynthesis. Shading should be used when plants are near maximum photosynthetic activity, but prior to the point of causing irreversible damage to the plants.

The shade material temperature is an important factor in determining the net radiation on the plants. Shading can be used to save half of the required water without sacrificing yield.

Shade cloth temperature

In the early 2000s, North Carolina State University agricultural engineer Dan Willits studied how growers struggled to sufficiently cool greenhouse crops during summer months. For some growers, fan ventilation and evaporative cooling represented the first two stages of cooling. The practice of installing a black shade cloth over the greenhouse had been adopted by some growers as a technique for further cooling the structure. Willits found there was little to no thermal improvement (reduction in greenhouse temperature) from using black shade cloth with low levels of shade (~30 percent). Heavier levels of shade were inefficient at reducing the temperature. Heavier shade reduced light levels consistent with the shading value, but not the heat load. This results in hot, low-light conditions.

Willits speculated that the temperature of the black shade cloth increases as it absorbs solar radiation. The heated shade cloth becomes a radiator decreasing its effectiveness as a net radiation reducer.

Willits demonstrated through modeling and full-scale testing that by cooling the shade cloth with water, the heat gained in the greenhouse and the floor temperature declined and were directly proportional to the shade cloth temperature. He concluded the reduction of shade cloth temperature by any means would improve greenhouse cooling efficiency.

Type of shade cloth

In further studies, Willits examined the use of reflective, externally mounted shade cloth to lower greenhouse temperature. The idea was that less absorptive/more reflective materials would result in lower shade temperatures and net radiation entering the greenhouse. Cloth materials tested included 60 percent shades of black cloth, reflective aluminum foil knits and reflective white/black knit films with the white side facing up. At the 60 percent shading level, the greenhouse heat gain for both reflective materials decreased by approximately 30 percent. This meant both the temperature rise of the greenhouse (inlet to exhaust) and leaf temperature were significantly reduced. GM

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ON THE COVER:

Greenhouse Management conducted an exclusive market research study on the impact Central American plant material is having on the U.S. ornamental plant industry. U.S. growers discuss the concerns and benefits they have with the increasing amount of plant material being shipped from Central American countries.

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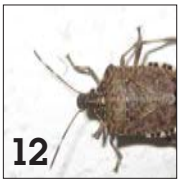
COVER STORY



FEATURES

DEPARTMENTS:

COLUMNS:

gie media incorporated

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