Greenhouse Shading

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The shading of greenhouses is a more complex problem than first meets the eye. It hasn't been that long ago that the standard belief behind recommendations for designing shading systems was that shade cloths reduce temperatures proportional to the amount of shading (light blockage) provided by the material. What actually happens in practice, however, was discovered by us only by accident.

In an attempt to improve the cooling ability of rockbeds, we used a 30% black plastic shade cloth over the rockbed house. What we found was almost exactly the opposite of what we expected; i.e., neither air temperature nor cooling were appreciably affected. At that time, it was not possible to say what exactly was happening because the study had been designed for another purpose and the instrumentation was insufficient to pinpoint the cause. What followed was series of studies into shade cloth performance to try to explain this apparent contradiction, the results of which are presented below.

Field Study

After the initial test referred to above, a follow-up study was conducted in the summer of 1987 using two 20' × 40' computer controlled greenhouses, one designated the test house and the other the control house. Inside the houses, relative humidity, air, leaf and ground temperatures were measured while solar radiation, wind speed, wind direction, air temperature and dew point temperature were measured outside. Tomatoes were planted in the houses 4 weeks prior to application of a 30% black plastic shade cloth to the test house. Data from before and after shade cloth application were compared in an effort to determine performance.

Due to space limitations, only data from a single day prior to shade cloth application (Figure 1) and a single day following shade cloth application (Figure2) will be presented here. Note that prior to shade cloth application, temperatures in the two houses were nearly identical while afterwards ground temperatures did decrease some; however, air and leaf temperatures actually increased. Some of the data (not shown) actually does show a slight decrease in air temperature with shading (0.5 to 1.0°F) but no evidence of reduced leaf temperature was observed. It was obvious that the shade cloth was acting as a barrier to cooling as well as an aid to cooling but the exact reasons for the blockage were still not clear.

Laboratory Study

Since the results obviously disagreed with the existing recommendations a laboratory study was initiated in which a model greenhouse was used to investigate the ability of various shading materials to reduce temperatures in a ventilated greenhouse. Black plastic, white painted plastic and white fabric (polyester) materials of various weaves were tested and the results compared to a computer model of the test facility.

The computer model showed that the basic reason shade cloths fail to perform as expected is that in the process of shading they also absorb energy. This enrgy must be rejected, some to the outside environment and some to the inside. Further, in addition to blocking solar energy from coming into the greenhouse shade cloths also block thermal energy from leaving the greenhouse. In combination, these factors act to reduce shading effectiveness in cooling.

The results of the material testing were that the black plastic materials averaged only 48%

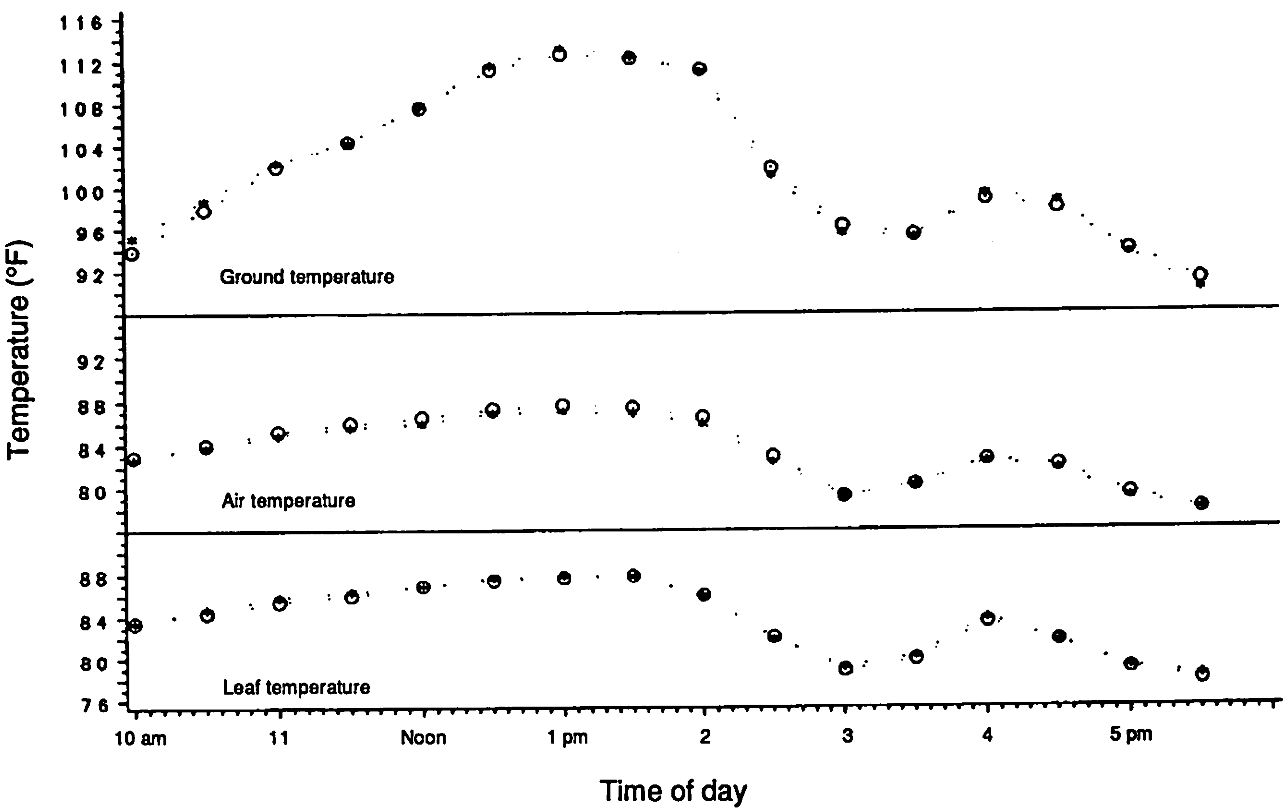

Figure 1. Temperatures in the test house (o) and control house (*) prior to application of the shadecloth.

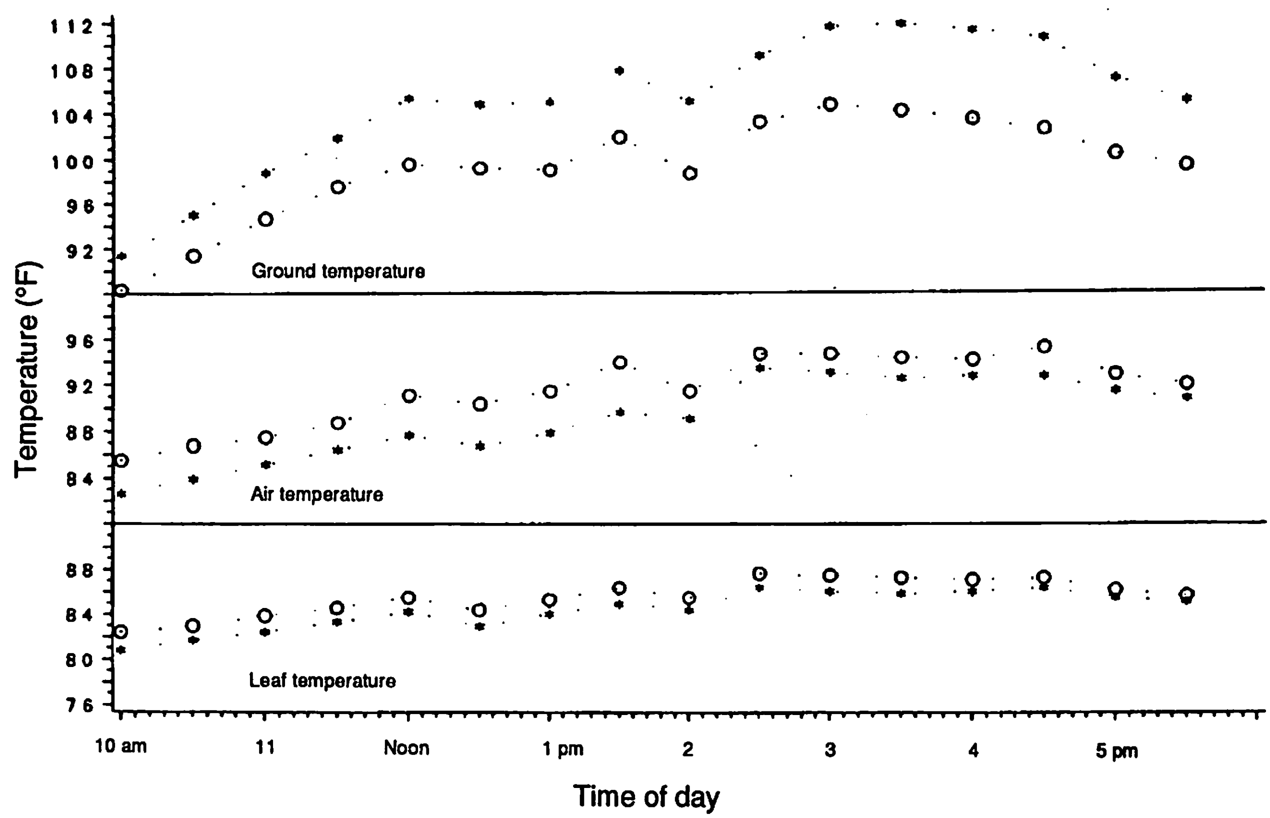

Figure 2. Temperatures in the test house (o) and control house (*) after application of the shadecloth.

effective (that is, temperatures were reduced only 48% of the amount predicted by the shading percentage) in still air and 63% effective with an outside air velocity equivalent to 5 mph. White painted plastics performed only slightly better (56% and 71%, respectively). The best performance was from the white fabric materials which were 88% and 102% effective, respectively (the 102% was probably due to the normal instrumentation error associated with tests such as these).

The results suggest that black plastic materials make very inefficient shade cloths, absorbing large amounts of solar energy which then cannot be easily rejected. White plastic shade cloths apparently are slightly better; however, they still do not reduce temperatures in proportion to "light" blockage. Excessive light blockage is an undesirable byproduct of temperture control through shading.

The best performing materials were the white fabrics; however, the reasons for that are still unknown. All of the white fabrics tested had very fine "hairs" protruding from the main fibers which may have increased the ability of the material to reject heat. It was also noticed, when testing for light blockage, that these materials seem to "luminesce" in sunlight, suggesting that they may have the ability to transmit light better than "heat." The disadvantage of the white fabric materials is that none of those tested could be considered "weather resistant" and they will not tolerate greenhouse conditions well. A better understanding of shading materials is needed and currently, studies are underway for exactly that purpose.