USE OF LOW TUNNELS TO IMPROVE PLANT GROWTH IN HIGH TUNNELS

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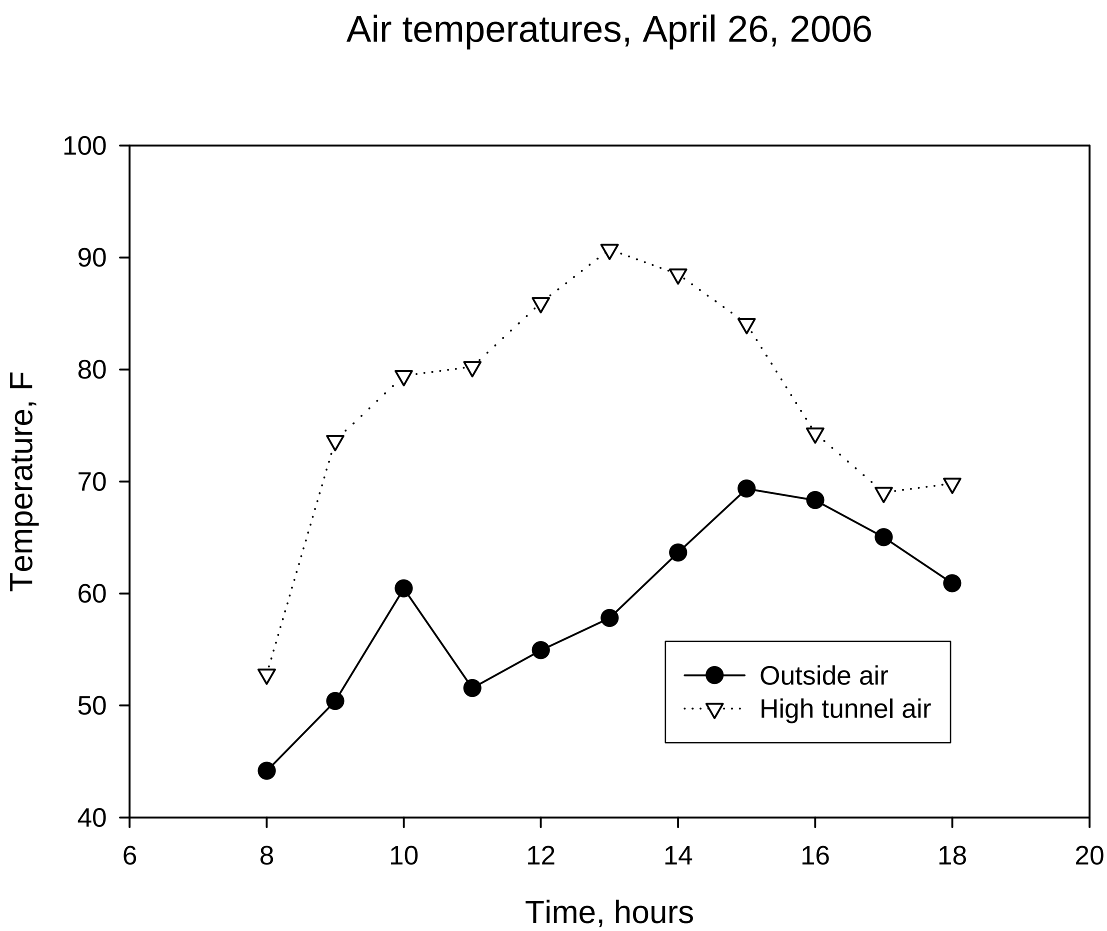
During the early spring, the threat of frost and wet conditions limit early planting of horticultural crops in the Northeastern US and Canada. Simple, inexpensive greenhouses, covered with a single layer of clear polyethylene plastic, can allow the soil to dry out and provide daytime temperatures favorable for growth. The warming effect of the spring sunshine in one of these tunnels can be considerable (Fig. 1), with maximum air temperatures climbing to above 90 F on a sunny day that only gets to 65 F outside.



First-time high tunnel users expect these daytime warm conditions to be maintained at night, but are surprised to find that on cold, clear nights, the air temperature in the tunnel drops to the temperature outside or lower. The reason for this is that the plastic film is transparent not only to visible light, but also to the invisible long wavelengths that represent infra-red or heat energy. During the day, so much of that energy is coming in from the sun that the temperature goes up in the tunnel, but at night, that source is shut off, and the heat can escape quickly.

Are there ways in which we can stop, or at least slow down, the rapid drop in high tunnel temperatures at night? Plastic manufacturers have been puzzling over this problem for many years, and have developed films which have a compound incorporated that partially blocks heat from escaping. These are the so-called "IR blocking films" that are readily available from plastic manufacturers. In a 2-year project sponsored by the New York Farm Viability Institute, we compared the performance of some of these products, with conventional films. One test was conducted on a grower's farm in Yates County, NY, the other at the Penn State High Tunnel Farm.

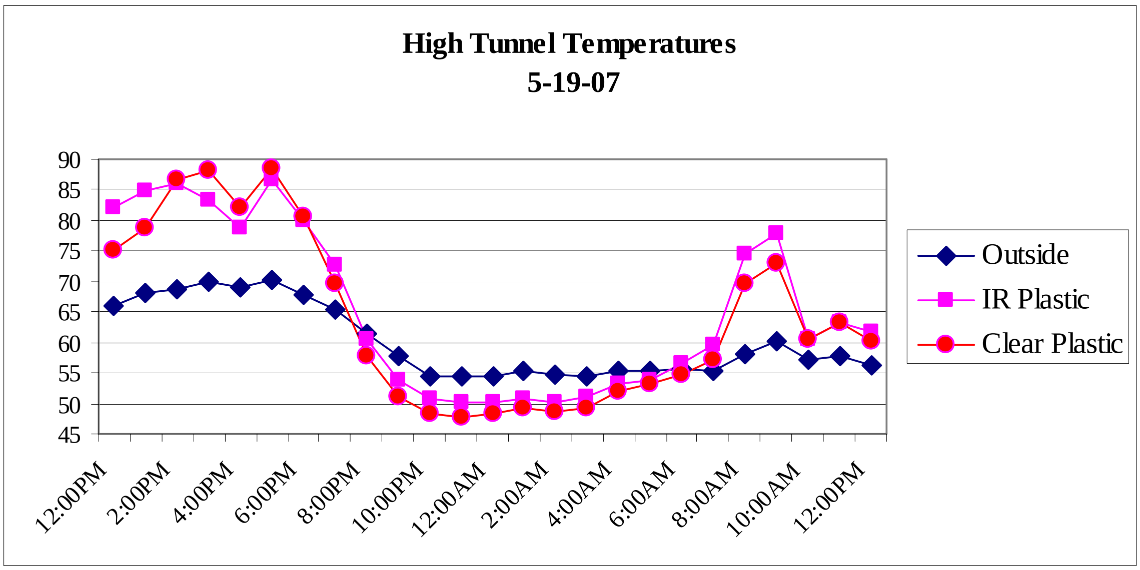


Fig. 2. Figure 2. Air temperatures within 2 high tunnels in comparison to outside temperatures from a 24 hour period in May 2007, Yates County NY.

In the Yates County comparison, the tunnel covered with conventional plastic reached lower temperatures early in the morning than was prevalent outdoors (Fig. 2). The tunnel with the plastic containing IR blocker was cooler than ambient early in the morning, but then warmed more quickly than the conventional tunnel and outdoors as the sun came up. The most likely explanation for this pattern is that the conventional film lets more heat escape than the IR-blocking film, but neither can completely prevent this heat loss. The small amount of heat rising from the soil in the tunnel allows internal tunnel temperature to increase even before the sun's energy starts to warm the tunnel again.

The Penn State tests compared temperatures of four identical high tunnels at the Penn State Tunnel Farm covered with four different materials, most of which contained IR blocking compound (Fig. 3). As in the Yates County example, Tufflite Control, which lacked an IR blocker, had the lowest temperatures, at one point about 6 F lower than the outside temperature. The other films kept the tunnels warmer, but also had periods during which the inside temperatures were lower than outside.

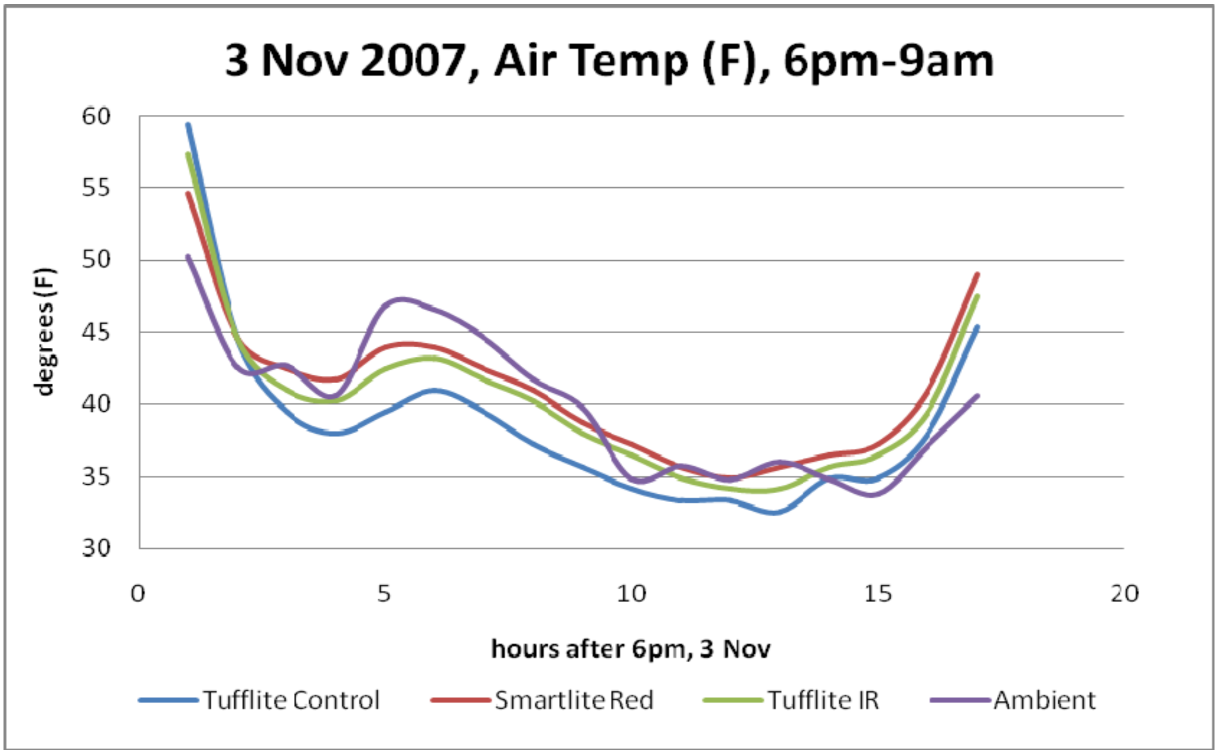


Fig. 3. Time course of air temperatures in three high tunnels at the Penn State High Tunnel Farm, covered by 6 mil polyethylene to which IR blocking compound had been added (Smartlite Red and Tufflite IR), and one covered by Tufflite without IR blocker.

The results indicate that polyethylene tunnel films with IR blocker are not the complete solution to the low temperatures in high tunnels, and additional techniques are needed.

The solution which many high tunnel growers have adopted is to use low tunnels directly over the crop growing in the high tunnel. This additional layer of fabric or film reduces heat loss from the soil, and can make a substantial difference to night air temperatures around the crop (Fig. 4). The thicker low tunnel cover materials kept the air temperature around the plants about 10 F higher than temperatures outside the tunnel. Without low tunnel protection, temperatures around the plants in the high tunnel on this night went down to freezing. The high tunnel was covered with IR-blocking plastic.

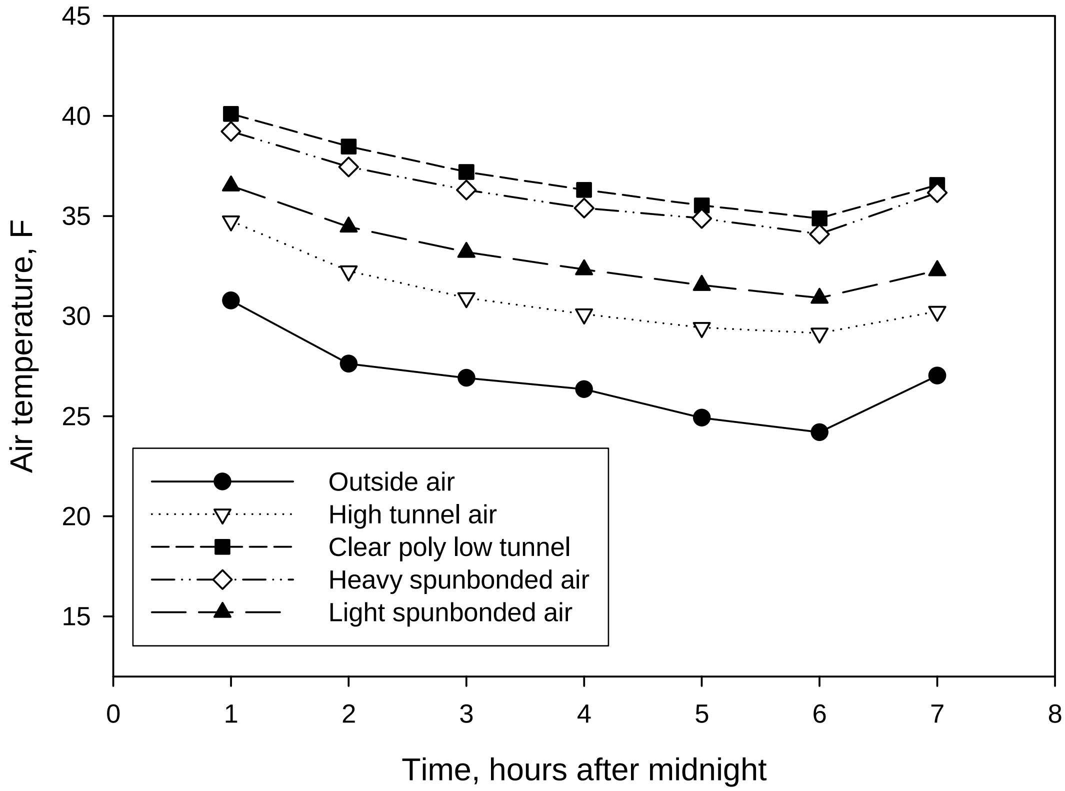


Fig. 4. Air temperatures outside, in a high tunnel, and under low tunnels situated in the high tunnel, on April 26, 2006. The low tunnels were covered with 6 mil clear polyethylene, or Covertan non-woven fabric, 0.6 oz/yd^2, or floating row cover, 2.0 oz/yd^2.

If using low tunnels to protect high tunnel-grown plants at night, it is tempting to keep the low tunnel cover in place during the day as well. Our results indicate that all except the lightest of the non-woven fabrics allow the temperature in the low tunnel to rise to high levels during the day, so it is important to ventilate the low tunnels by pulling them back in the morning, and putting them in place again late in the day. The humidity also tends to rise to high levels in the low tunnel when left in place during the day, encouraging disease.

These trials, conducted in farmers' high tunnels and at the Penn State and Cornell experimental tunnels, indicate that temperature management for optimum plant growth in high tunnels requires vigilance by the grower, and a combination of high and low tunnel covers to prevent frost damage early and late in the growing season.

We are grateful for the sponsorship of the NY Farm Viability Institute for this research.