HEAT EXCHANGE THROUGH BLACKCLOTH AND BLACKCLOTH SUBSTITUTES

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Several types of plastic film have been used as less expensive substitutes for the black sateen shade fabric (blackcloth) commonly used in commercial greenhouses to shorten the day length for off-season flowering of chrysanthemums and other crops. Films for this purpose should be strong, durable, and completely opaque. In addition, they should have good heat exchange properties, because heat buildup under such coverings pulled in the late afternoon before the sun sets can damage plants (Nelson, 1967).

The heat-exchange process is this: Initially, the sun's radiation is absorbed by the material and is conducted to the air inside. As the temperature inside increases, the rate of energy loss from the material also increases until it just balances the rate at which the incoming radiation is absorbed. At this point, the temperature under the covering remains constant and often excessively high, depending on the covering material.

During the summer, growers sometimes delay pulling blackcloth for an hour or two to avoid possible plant damage. A more practical approach may be to use a covering material that either absorbs radiant energy at a low enough rate or re-radiates it at a high enough rate to keep temperatures at acceptable levels. A film that is reflective on one side and black on the other should serve the purpose. One such material is made of co-extruded black and gray polyethylene. A preliminary experiment was conducted at San Jose to compare its heat exchange properties with that of regular black and clear polyethylene films, blackcloth, and aluminum foil.

Small cylinders were covered with the materials (fig. 1 and 2). Temperature changes within the cylinders were then measured as they were cooled down in the dark or heated by the sun. Figure 3 illustrates the "cool-down curves" for the coverings. The rate of energy loss through a particular film can be estimated by considering the energy loss required to give any specific rate of temperature decrease. Those given in the legend of figure 3 have the same units as the thermal conductance values reported by White and Aldrich (1975). Discrepancies between the two probably relate to differences in methods used to obtain measurements.

Fig. 1. Local plant expert Dennis Suit holding a cylinder assembly used for evaluating films. It is 10 inches long and 4 inches in diameter with ¾-inch plywood ends and sidewalls of 1-inch steel mesh. Cylinder shown is covered with clear polyethylene. Thermometer bulb is shielded to prevent direct absorption of sunlight.

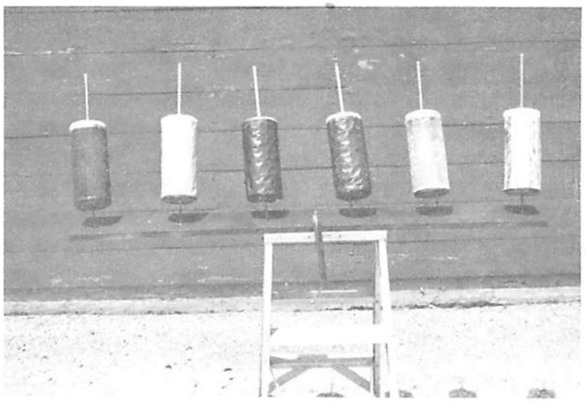

Fig. 2. Cylinders positioned for determining warm-up curves are covered with the following materials, left to right: black sateen shading fabric; Plant Fresh Film®, gray side out; Plant Fresh Film®, black side out; black polyethylene film; clear polyethylene film; aluminum foil. All plastic films are 0.004 inch (4 mil) thick.

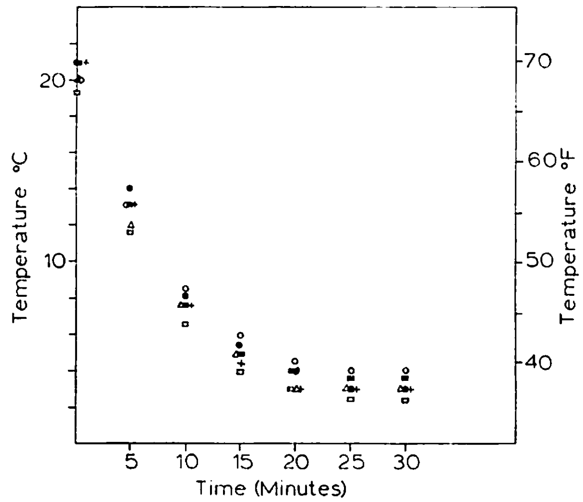

Fig. 3. Cool-down curves. Cylinders were removed from a 70°F (21°C) oven and placed in a cold box set at 35°F (1.7°C). Final temperature differences reflect thermometer variations. Symbols and thermal conductance values — $\frac{\text{BTU}}{(\text{hr.})(\text{sq. ft.})(°\text{F})}$ — are as follows:

- ● aluminum foil, 0.27
- ■ black polyethylene, 0.31
- □ Plant Fresh Film®, gray out, 0.31
- + Plant Fresh Film®, black out, 0.32
- △ clear polyethylene, 0.30
- ○ sateen blackcloth fabric, 0.27

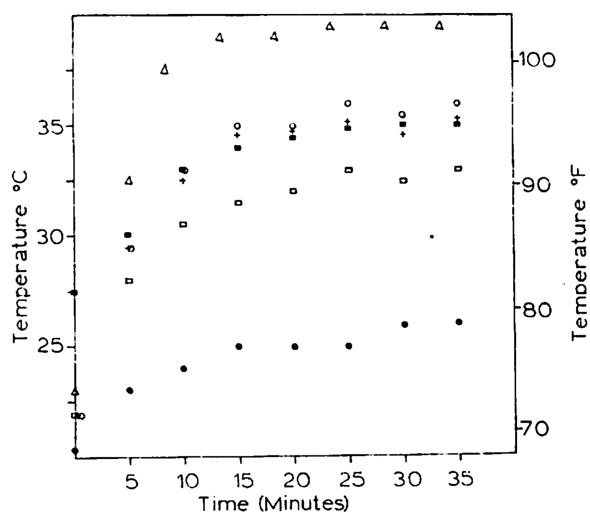

Fig. 4. Warm-up curves. Cylinders were placed in full sun at 1:00 p.m. (PDT) on May 22, 1975. Wind was light to calm, and the air temperature was 71° to 75°F (22° to 24°C). Symbols have the same meaning as in fig. 3.

The cool-down curves and the estimates of thermal conductance are similar for all of the materials tested. The "warm-up curves" obtained when the cylinders are placed in the sun (fig. 4) are not all similar. The cylinder covered with the most reflective material (aluminum foil) remained considerably cooler than those covered with less reflective materials. The one covered with the co-extruded plastic placed gray side out was intermediate in equilibrium temperature and remained cooler than the cylinder covered with the same material placed black side facing out. The latter reached the same equilibrium temperature as the cylinders covered with regular black poly and blackcloth.

The temperature differences reported here are not to be construed as estimates of differences to be expected when these materials are used on a large scale. However, it would be expected from these results that a greenhouse planting will remain cooler at a given level of solar radiation when covered with the co-extruded plastic placed gray side out than when covered with blackcloth. Experiments are in progress to determine if such a difference would be large enough to be advantageous to a commercial grower.

LITERATURE CITED

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