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SHADING FABRICS: TRANSMISSION CHARACTERISTICS UNDER PLASTIC GREENHOUSE COVERS

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Various shading cloths were examined for transmission of sunlight, showing some rather interesting differences as the result of greenhouse cover. The manufacturer's designation did not always indicate actual percent reduction.

An article on shading (March, 1983, Greenhouse Manager) made reference to the methods used by shade fabric manufacturers to determine the light reduction characteristics of their products. An artificial light system, perpendicular to the fabric is used to establish the percent transmission of their products.

In April, 1984, three major "shade cloth" manufacturers were approached regarding a cooperative research program to determine the "shade" capabilities of their individual products when installed under a variety of plastic greenhouse covers. One supplier, V-J Growers Supply, responded to the proposed program and provided a set of fabrics for the evaluation.

PROCEDURE

The solar energy transmitted through five "shade cloth" fabrics, "30, 40, 50, 60 and 70 percent", was evaluated in June and July, 1984, during periods of unobstructed solar radiation and throughout the daylight hours. Calibrated MK 1-G Sol-A-Meter pyranometers (350-1100 nanometer range) were used to sense the irradiance levels and data were recorded on a digital recorder.

Part I: Outdoor Transmission Characteristics of Fabrics

A 4 × 10 × 10 foot pipe structure was constructed so the 20 × 20 foot pieces of shade fabric could be draped over the framework (Fig. 1), and solar transmission characteristics evaluated in unobstructed outdoor conditions. A series of measurements were made between 1130 and 1430 hours MST using the "50 percent" shade cloth to determine if the distance from the sensor to the fabric would influence the recorded readings. There were no differences in the percent solar radiation transmitted by the fabric as a function of distance from the sensor (Table 1). However, the fabric reduced transmittance slightly more than the manufacturer's specifications.

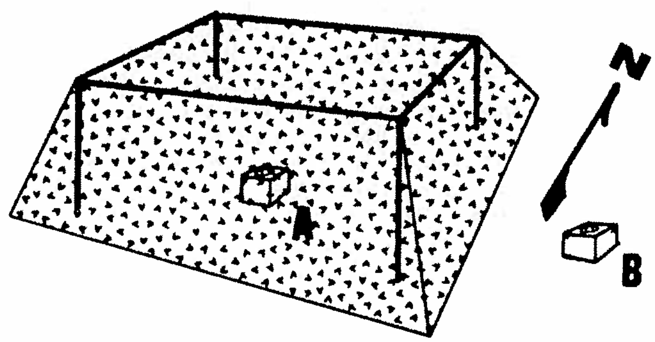

Fig. 1. Frame structure used to determine the percent solar radiation transmitted by various shade cloth fabrics. Pyranometers were located at position A & B.

Table 1. The percent solar radiation transmitted by a "50 percent" shade fabric at various distances from the material.

Distance between fabric and sensor (inches)	% Transmission
1	48%
6	48%
22	46%
45	47%

A second evaluation using the frame was conducted to determine if a "40 percent" shade cloth would provide the same irradiance throughout daylight hours. The percent transmission varied during the day, (Fig. 2), averaging 45 percent. The greatest solar radiation was transmitted at noon when the fabric was perpendicular to the sun. The

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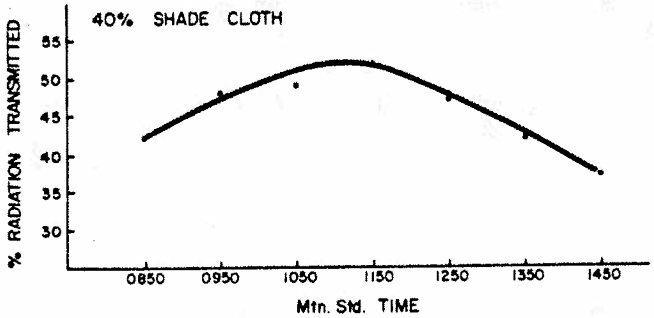

Fig. 2. Percent solar radiation transmitted by a "40%" shade cloth fabric from 0850 to 1450 hours, 28 June, 1984, a clear day.

fabric material, as well as position of the sun, can influence the percent solar radiation transmitted by a shade cloth material (Fig. 3).

All five shade cloth fabrics were placed over the pipe structure during a five day period. A minimum of 10 readings were taken between 1130 and 1430 hours MST, the period of time when the sun had minimal changes in altitude. The five shade cloth fabrics transmitted less solar radiation (created more shadow) than designated by the manufacturer, (Table 2). The data also indicated there were no differences in the transmission characteristics of the "40 and 50 percent" fabrics.

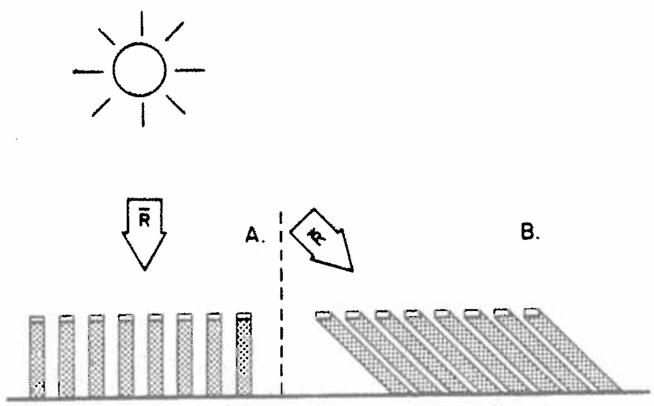

Fig. 3. Graphic description showing how the threads of a shade cloth fabric will provide minimum shadow when the sun is perpendicular to it (A.). The shadow will increase as the sun moves from the perpendicular position.

Table 2. The effect of fabric weave and density on the transmission of solar radiant energy.

Manufacturer's designation	Measured transmission % of solar outside	Actual percent reduction by fabrics (corresponds to mfg. specifics.)
30%	65	35
40%	47	53
50%	47	53
60%	34	66
70%	24	76

Part II: Fabric Installation Inside Greenhouses

Four quonset type greenhouses, with different plastic covers, were used to evaluate the additive effects of the covers and the various shade cloth materials. The covers included: 3-year-old double layer Tedlar® covered panels (PVF panels), 5-year-old single layer, 5 ounce Tedlar® coated fiberglass reinforced plastic panels (FRP), 2-year-old, air-inflated DuPont 603® polyethylene (double poly) and 1-year-old double layer, air-inflated Tedlar® films (double PVF).

The pyranometers were positioned 3 feet above the ground (Fig. 4) in the greenhouses and calibrated prior to the installation of the shade cloth fabrics. The fabrics were rotated in each greenhouse and data recorded on cloudless days from 1130 to 1430 hours MST.

The transmission characteristics of all fabrics were affected by the type of greenhouse cover (Fig. 5). The FRP cover in the "30 percent" shade cloth column transmitted 89 percent of the total outside solar energy. When the radiant en-

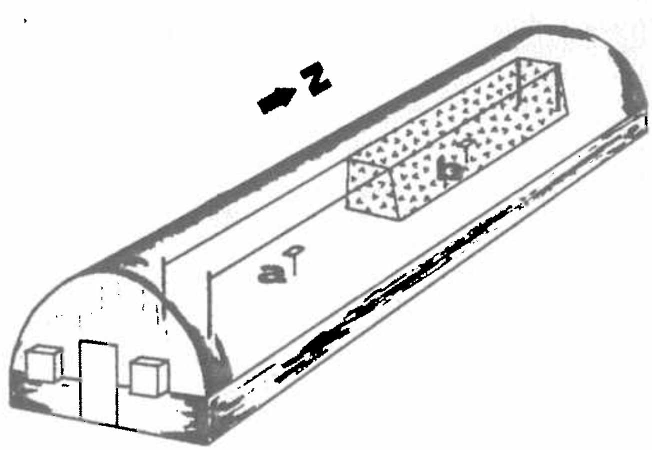

Fig. 4. Position of the shade cloth fabrics in each greenhouse during the evaluation. Pyranometers were positioned on holders a and b, and on the roof of the greenhouse.

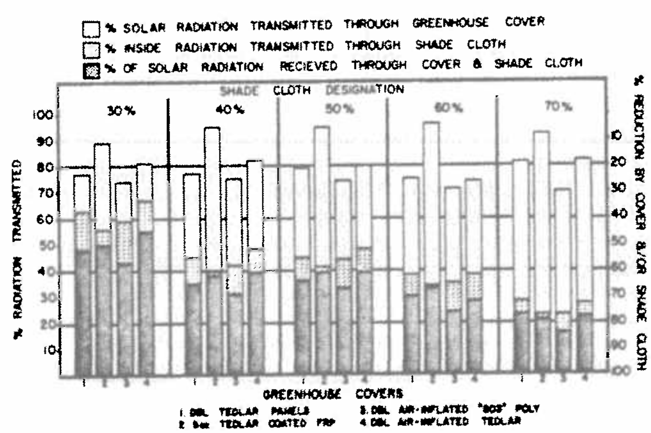

Fig. 5. Percent of outside solar radiation transmitted through four greenhouse covers, and combinations of five shade cloth fabrics located inside the structures, from 1130 to 1430 hours MST, on cloudless days, 18-22 July, 1984.

ergy in the greenhouse was compared to that under the fabric, the shade transmitted only 56 percent of the total inside radiation. The additive effects of the FRP cover, plus the "30 percent" shade fabric, allowed only 50 percent of the outside solar energy to be measured under the fabric. Proportional relationships existed between shade cloth densities and other greenhouse covers. The least outside solar radiation, 16 percent, was transmitted by the "70 percent" fabric in the 603® double poly covered greenhouse. This combination of materials reduced the transmission of outside sunlight 84 percent.

Following the last rotation of fabrics between greenhouses, the shade cloths were left in the various houses to determine the accumulative transmission characteristics from sunup to sundown (Table 3).

The percent of solar energy transmitted by the greenhouse covers throughout the daylight hours was less than that observed at high noon. Angles of incidence and reflection are attributed to the changes. The percent radiant energy transmitted by the shade cloth in the greenhouse and through the greenhouse cover, plus the fabric, also differed from the "high noon" readings.

Part III: Exterior Installation of Shade Fabrics on Greenhouse Roofs

An installation of shade cloth fabric had been seen on the roof of an arch type greenhouse at Frampton's Inc., a Charleston, South Carolina, flower producer. Upon viewing the installation, the question of shade cloth efficiency became the topic of conversation and led to this part of the study.

The shade cloth fabrics used in Part I and II were placed on half of each greenhouse roof (Fig. 6). Based on the data obtained (Fig. 7), there was little difference in the shading effects of the fabrics located in the greenhouse versus their placement on top of the greenhouse cover. The shade effect decreased slightly when the fabric was placed over the greenhouse cover and the shade reduction characteristics were closer to the manufacturer's designations.

DISCUSSION

The results of this evaluation clearly demonstrate the need for growers to determine the irradiance levels in their greenhouse throughout the crop growing period. With such information, they can design a shade cloth system, or apply a shading compound, to meet their needs. It is apparent that different greenhouse covers transmit dissimilar intensities throughout a cloudless day (Fig. 5). The presence of a shade cloth will further reduce the intensity inside a greenhouse, but not the same amount as designated by the fabric manufacturer. Proper radiation sensing instruments must be used to insure adequate energy for desirable plant growth. Instantaneous light readings should be taken when the sun has reached its zenith, "high noon", because this is the period of greatest solar radiation on a cloudless day (Fig. 3). Radiation control must be designed for that maximum level.

Overshading delays crops, contributes to stem elongation and can be attributed to lower plant or flower quality. Undershading can also be detrimental. It can increase plant stress due to high foliage temperatures and water loss (evapotranspiration). Plant growth can be delayed and in many instances foliage and flowers "burned".

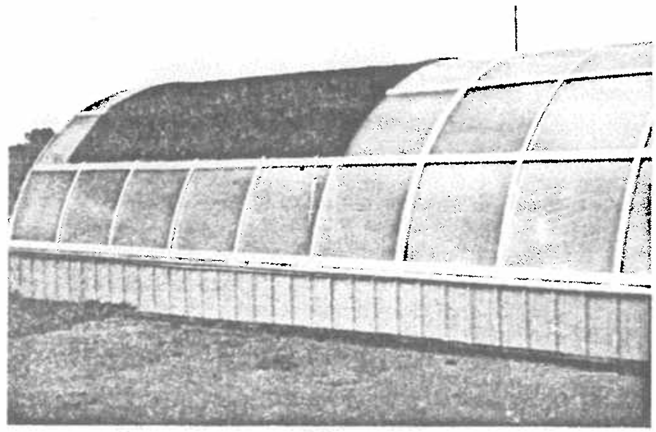

Fig. 6. Position of different shade cloth fabrics on the covers of the quonset greenhouses.

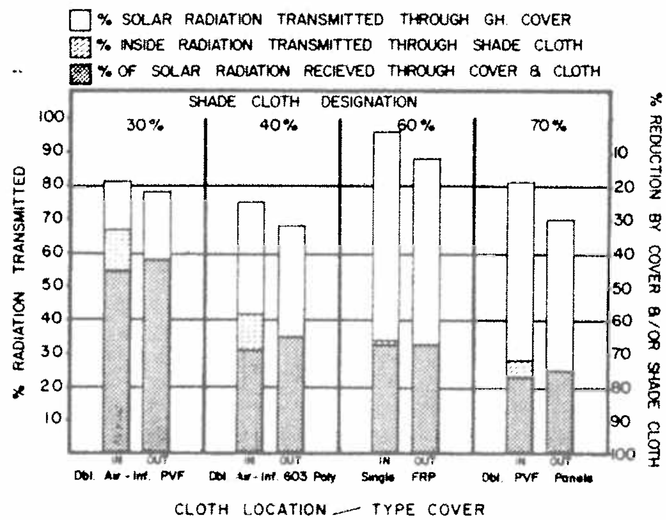

Fig. 7. Comparison of outside solar energy transmitted by shade cloth fabrics located inside individual greenhouses, and outside on top of the glazings, from 0850 to 1450 hours MST, on 30-31 July, 1984, cloudless days.

Table 3. Transmission characteristics sunup to sundown, of shade cloth fabrics located inside different plastic covered greenhouses. ( ) actual % reduction by greenhouse cover and/or shade cloth.

	Manufacturer's fabric designation and test cover				
	30% Dbl PVF	40% Dbl POLY	50% Dbl POLY	60% FRP	70% PVF Panels
Transmitting condition	**Percent of outside or inside radiation transmitted**				
Solar radiation through cover	73(27)	63(37)	65(35)	26(74)	68(32)
Inside through shade cloth	72(28)	42(58)	53(47)	30(70)	32(68)
Through cover plus shade cloth	53(47)	27(74)	35(65)	27(74)	22(78)

The installation of shade fabrics over the top of a greenhouse may serve a two-fold purpose: 1) provide the desired level of irradiance at plant height, and 2) extend the useful life of the greenhouse glazing, especially in the case of polyethylene. The shade fabrics should slow the photo-degradation process of plastics and perhaps add one or two years to the life of the product, unless it becomes brittle and falls apart.

Glass and structured sheet covered greenhouses were not available for inclusion in the foregoing evaluation. However, based on more than five years of glass transmission data, and two years of structured sheet results, all compared to film and rigid plastic covers, similar results involving the shade fabrics would be expected. When combinations of structured sheets and shade cloth are considered, the "high noon" transmission characteristics may not be as important as mid-morning or mid-afternoon information, especially if the ribs of the cover are perpendicular to the path of the sun.

Authors' Note: Appreciation is expressed to V-J Growers, Inc., Monsanto Company, Lasco Industries and DuPont for their participation.