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PLANT RESPONSES TO PLASTIC GREENHOUSE Covers: 1983-1984

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The quonset style greenhouses at CSU's W.D. Holley Plant Environmental Research Center have been used for greenhouse cover studies since their erection in 1975 (5). Fuel consumption and solar radiation transmission characteristics of 10 combinations of plastic glazings have been compared during the 9-year period. They include: single and double layer air-inflated "602" polyethylene, new and 10-year-old non-Tedlar® coated fiberglass reinforced plastic panels (FRP), Tedlar® coated FRP panels, Qualex polycarbonate structured sheets, Achilles 4 mil polyvinyl chloride film (Japan), "603" air-inflated polyethylene and most recently, double Tedlar® (PVF) covered panels and double air-inflated Tedlar® film. (2,3,4,5,6).

1983-84 Research

During the 1983-84 heating season, the quonset structures were covered with:

House 1: 4 mil dbl layer Tedlar® (PVF) panels, installed September, 1981
House 2: Sgl 5 oz. Tedlar® coated, LASCO FRP panels, installed September, 1979
House 3: Dbl layer air-inflated Monsanto 603 poly installed July, 1982
House 4: Dbl layer, air-inflated Tedlar® (PVF) film, installed September, 1983 (4 mil out, 2 mil inside)

Natural gas used for heating each greenhouse and solar radiation transmitted by the covers, was monitored from mid-September, 1983, through April, 1984.

The growth rates of tomato plants and rose flowers were used to determine plant responses to the four covers during spring, 1984. The plant environmental conditions for the 1983-84 rose experiment were comparable to those described by Ferare and Goldsberry (1) during the previous winter, except for CO_2 concentrations; the greenhouses were not enriched with CO_2 during the study period. The same nutrient and watering regime was also used.

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Solar Radiation Transmitted

The amount of solar radiation (insolation) transmitted by the various greenhouse covers was measured with calibrated MK 1-G Sol-A-Meter pyranometers (350-1100 nanometers) located 3 ft. above ground in the center of each house and recorded on a Kaye digital recorder. The total radiation transmitted by each cover ranged from 59 to 77 percent of the insolation on the greenhouse (Table 1).

The insolation received by the pyranometer in each house varied throughout the evaluation period (Fig. 1). The differ-

Table 1: Percent of total solar radiation transmitted through four greenhouse covers from September 17, 1983 to April 29, 1984.

	Installed	Percent Insolation Transmitted
4 mil, Dbl layer Tedlar® panels	September 1981	60
Sgl 5 oz Tedlar® coated LASCO FRP panels	September 1979	77
Dbl, air-inflated Monsanto "603"	July 1982	59
Dbl, air-inflated Tedlar®	September 1983	70

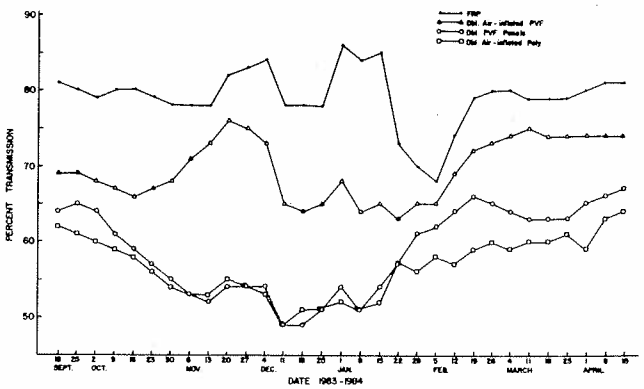

Fig. 1: Percent of solar radiation transmitted by four greenhouse glazings from September 17, 1983, through April 29, 1984, using three week moving means.

ences in the values obtained under the two Tedlar® covers were attributed to the presence of excessive condensate in, and on, the film of the panel-covered house and, to a degree, the additional superstructure involved in this rigid double layer installation.

Fuel Consumption

The houses were heated to 61°F nights, and 70°F days during the 1983-84 heating season. Fuel consumption from November 2, 1983, to March 5, 1984, varied from 3399 CCF in the FRP covered house to 1722 CCF in the Tedlar® air-inflated structure (Table 2).

Table 2: Fuel required to heat four greenhouses, having 960 ft² ground area, different covers, and heated to 61°F N and 70°F D from November 2, 1983, to March 5, 1984, a 124-day period.

	Nat. Gas used CCF	% of Sgl FRP	Cost per ft² Ground Area	Avg Daily Cost*
Dbl layer Tedlar® panels	2195	-35	$0.93	$7.23
Sgl layer FRP panels	3399	—	1.44	11.17
Dbl air-inflated "603"	2302	-32	0.96	7.42
Dbl air-inflated Tedlar®	1722	-49	0.74	5.70

*less taxes

Approximately 80 percent of the fuel used to heat the greenhouses for a year was used in the 124-day heating season. The reduced fuel required by the double air-inflated Tedlar® covered house was attributed to the increased effect of passive solar heating as evidenced by the high percent of insolation transmitted by the double cover (Table 1). It should be realized that the tests were not replicated and the recording and sensing equipment was accurate only within ±10 percent.

Plant Responses to Covers

Rose plant cultivars, 'Sonia' and 'Royalty', involved in the 1981-83 greenhouse cover research and reported by Ferare and Goldsberry (1), were also used in the 1983-84 project. The object of the 1983-84 study was to determine if the solar radiation transmitted by the four greenhouse covers influenced the time required to produce a spring crop of flowers.

The percent of total outside solar radiation transmitted by the covers during the evaluation period April 16 to June 24, 1984, was:

4 mil dbl layer Tedlar® panels	66%
Sgl, 5 oz Tedlar® coated, LASCO FRP panels	74%
Dbl, air-inflated Monsanto "603"	62%
Dbl, air-inflated Tedlar®	73%

All flowers harvested in each cover treatment after April 16, 1984 were categorized into two stem diameters, 4 mm and 7 mm, at the time they were cut. The flowers were cut leaving one five-leaflet leaf on the plant cane, which was tagged with the date of harvest, cultivar, stem size and replication number. Thirty-nine to fifty days later, each tag was removed along with the flower produced by the remaining five-leaflet eye and the harvest date recorded. The solar radiation received at plant level during the complete development of each flower was recorded. Statistical analysis used a split plot design.

The 4 mm diameter stems of 'Sonia' flowered two days sooner than either size 'Royalty'. However, the 7 mm 'Sonia' stems flowered significantly faster than the 4 mm flowers. Similar information is indicated in Fig. 2.

There was also a significant effect of the greenhouse covers on the rate of flower development during the 124-day evaluation period (Fig. 3). The faster development of flowers in the two double Tedlar® covered houses was attributed to better control of temperatures and higher humidity compared to the high "light" transmitting FRP covered structure.

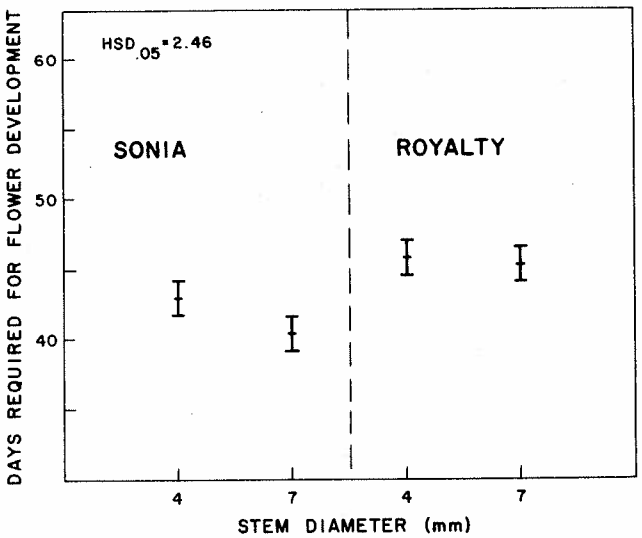

Fig. 2: Number of days required to produce a spring flower crop from rose cultivars 'Sonia' and 'Royalty' on stems of 4 and 7 mm diameter.

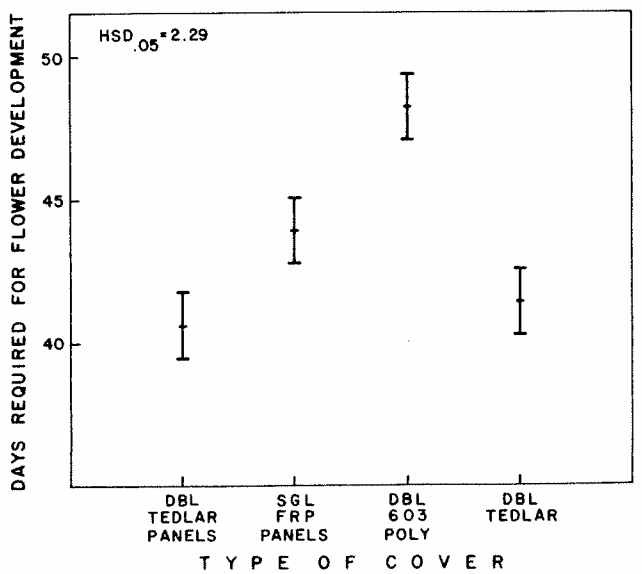

Fig. 3: Days required to produce flowers from the combined rose cultivars 'Sonia' and 'Royalty', grown under different plastic glazings during the evaluation period, April 16 to June 24, 1984.

The relationship of solar radiation transmitted by a cover, compared to the length of time required to produce a rose flower, is shown in Figures 4 and 5. It was evident that the rose cultivar 'Sonia' required fewer days to develop flowers than 'Royalty' at all light levels.

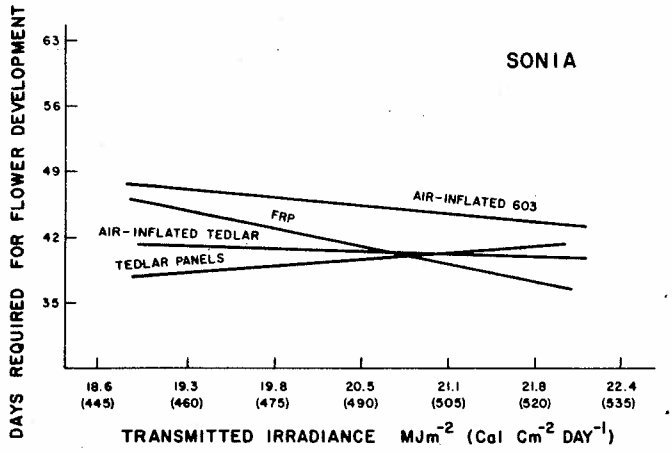

Fig. 4: Regression coefficients of the number of days required to produce a spring crop of flowers from the rose cultivar 'Sonia', grown under different plastic glazings and receiving various irradiance levels.

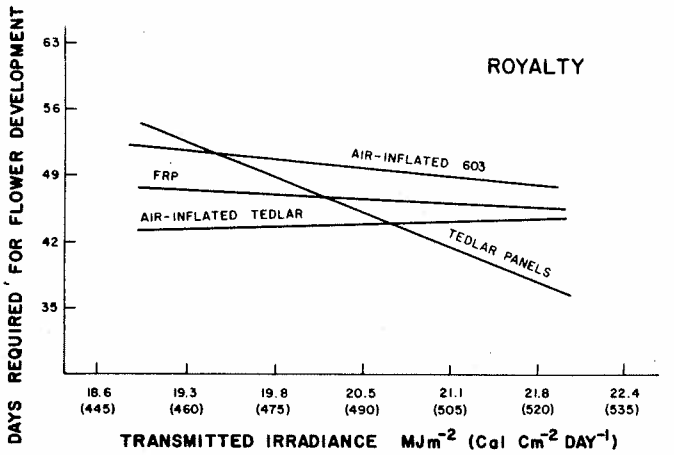

Fig. 5: Regression coefficients of the number of days required to produce a spring crop of flowers from the rose cultivar 'Royalty', grown under different plastic glazings and receiving various irradiance levels.

During a portion of the evaluation, the heating controls in the Tedlar® panel covered house malfunctioned and the air temperatures increased 2-3°C higher than those in the other three houses. It is interesting to note that the cultivar 'Royalty' responded to the higher temperatures by flowering faster (Fig. 5) and 'Sonia' appeared to have had almost the opposite response (Fig. 4), the rate of flower development decreasing slightly.

Tomato plant responses, starting with the true leaf seedling stage, were evaluated under the different covers from May 7th to June 4th, 1984. Relative growth and net assimilation rates, specific leaf areas and leaf weight and leaf area ratios of the cultivar 'Labrador' were calculated.

There were no apparent differences in tomato plant responses during the evaluation period. It was concluded the glazings transmitted adequate energy at that time of year, and plants grown under all greenhouse covers were "light" saturated. In order to evaluate the effects of the glazings on tomato growth, a similar study will have to be conducted from November through February, at a future date.

Conclusions and Discussion

The four year old FRP greenhouse glazing transmitted the greatest percentage of solar radiation during the 1983-84 winter. The double layer air-inflated, Tedlar® transmitted 7% less during the same period of time, but was comparable to the FRP in the spring, when the plant growth study was conducted.

Previous research with carnations (6) indicated that flower production and days to flower were reduced when insolation transmitted by a cover approached 69% for the winter growing months. In this evaluation, the transmission conditions under the "603" cover (62%) and the time required to produce a crop of roses, was lengthened compared to the other covers.

The solar radiation transmitted by the double Tedlar® coated panels was reduced by the presence of condensate between the film layers in December and January (60% transmission). But, during April and May, the condensate was reduced and 66% of the outside radiation was transmitted. It is possible that the threshold of radiant energy that influences the growth of the two rose cultivars used in this evaluation was between 62% ("603 levels) and 66% (Tedlar® panel levels) of the available solar radiation. Research planned for 1985-86 should determine if such a conjecture is true. A flower quality index will also be included.

Lastly, the differences in responses of the two rose cultivars to the cover treatments indicate that at least three cultivars should be used in greenhouse rose physiology research. Too often, one cultivar is involved and the results can be misleading — researchers and growers alike usually accept the results as "gospel".

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