COLORADO FLOWER GROWERS ASSOCIATION

Bulletin 351 | Edited by David E. Hartley | September 1979

# OBSERVATIONS ON TEMPERATURES, HUMIDITY AND LIGHT IN POLYETHYLENE-COVERED GREENHOUSES

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Polyethylene has become a common greenhouse covering in recent years, particularly in warm, Mediterranean-type climates where structures are often unheated. It is well known that polyethylene, upon which there is no condensation, will transmit infrared radiation as contrasted to glass or fiber-reinforced plastics, and this factor will often influence internal greenhouse temperatures. Double polyethylene layers are often cited as saving 30 to 40% of the usual energy requirements over single layers when heating is required, but that double layers will cause a significant reduction in light intensity. There may be a tendency to assume that double layers will also save energy even though the house is unheated. The latter two statements do not appear to be universely true, based upon some preliminary measurements made at the Akhelia Agricultural Research Station in Cyprus.

Three pipe-frame greenhouses, with 6-ft eaves, were covered with polyethylene November, 1978. Two houses, 16 × 36-ft, were covered with double-air inflated layers, however, one was never heated throughout the season, the second had heat installed in January, 1979. A third house was covered with a single polyethylene layer, following conventional construction. All houses were oriented nearly to an east-west direction with the crops in the ground or in plastic buckets set on the ground.

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A series of temperature, relative humidity and light intensity measurements were made on several consecutive days January and March, 1979.

## Results

There was no statistically significant difference between inside and outside air temperatures for either double polyethylene or single polyethylene roofs in unheated greenhouses in the early morning hours prior to sunrise (Table 1). Although the west, double poly house, had an average temperature 2.4°F higher than its identical twin on the east, it was felt this was due more to position, and possibly to errors between the thermometers. Heating the house obviously made a difference, but throughout the entire period, the type of roof made no difference in regard to heat conservation, in an unheated structure, and the internal temperature was essentially the same as the outside temperature shortly after sunset (Table 1). Under conditions of clear skies, it was not uncommon to have inside night temperatures lower than the outside, although the averages in Table 1 do not show this clearly.

Heating the greenhouse provided a significant decrease in relative humidity, even though the greenhouse remained closed all night (Table 2). There was no difference between single and double layers otherwise. Ventilating the greenhouse at night, tended to reduce internal relative humidity, but it was not significantly lower. The common practice of closing the greenhouse prior to sunset in order to conserve heat, under these climatic conditions, failed to do

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Table 1: Temperature measurements in polyethylene-covered greenhouses, 1979. Temperature measured with thermometers immersed in 1 quart containers of water, shielded with aluminum foil. Readings taken before sunrise each morning, except the last set.

| Dates of observations | Number of observations | Conditions of observations | Temperature (°F) |
|---|---|---|---|
| 9 Jan - 26 Jan | 15 | 1. Air-inflated, double poly, unheated. | 51.1 |
| | | 2. Air-inflated, double poly, unheated. | 48.7 |
| | | 3. Single poly layer, unheated. | 49.6 |
| | | 4. Outside | 49.1 |
| | | Difference required for significance | none |
| 27 Jan - 11 Feb | 16 | 1. Air-inflated, double poly, heated. | 59.9 |
| | | 2. Air-inflated, double poly, unheated. | 52.9 |
| | | 3. Single poly layer, unheated. | 53.4 |
| | | 4. Outside | 52.2 |
| | | Difference required for significance | 3.1 |
| 13 Feb - 23 Jan | 11 | 1. Air-inflated, double poly, heated. | 62.2 |
| | | 2. Air-inflated, double poly, ventilated at night. | 53.4 |
| | | 3. Single layer poly, unheated, unvented. | 54.0 |
| | | 4. Outside | 53.4 |
| | | Difference required for significance | 3.1 |
| 12 Feb - 22 Feb | 10 | 1. Air-inflated, double poly, unheated, before ventilation, after sunset. | 59.7 |
| | | 2. Outside, after sunset. | 58.1 |
| | | Difference required for significance. | none |

Table 2: Relative humidity in heated, unheated, ventilated and unventilated, polyethylene greenhouses.

| Dates of observations | Number of observations | Conditions of Observations | Humidity (%) |
|---|---|---|---|
| 25 Jan - 11 Feb | 17 | 1. Air-inflated, double poly, heated, prior to sunrise. | 87 |
| | | 2. Air-inflated, double poly, unheated, prior to sunrise. | 93 |
| | | 3. Single poly layer, unheated, prior to sunrise. | 93 |
| | | 4. Outside, prior to sunrise. | 78 |
| | | Difference required for significance | 5 |
| 12 Feb - 23 Feb | 11 | 1. Air-inflated, double poly, heated, prior to sunrise. | 89 |
| | | 2. Air-inflated, double poly, unheated, ventilated all night, prior to sunrise. | 83 |
| | | 3. Single layer poly, unheated, unventilated, prior to sunrise. | 93 |
| | | 4. Outside, prior to sunrise. | 69 |
| | | Difference required for significance. | 13 |
| 12 Feb - 22 Feb | 10 | 1. Air-inflated, double poly, unheated, after sunset, prior to ventilation. | 87 |
| | | 2. Outside, after sunset. | 71 |
| | | Difference required for significance. | 12 |

so, and merely increased humidity, increasing disease problems. The standard recommendation should be that if one has an unheated greenhouse — not very common in Colorado — the structure should be deliberately ventilated throughout the night hours, beginning shortly after sunset.

The most surprising result was that determinations of direct sunlight in single and double poly structures showed no significant differences when averaged over all conditions (Table 3). The average reduction in outside light for both types, all conditions, was about 41%. The factor which was decisive was the amount of condensate, which was invariably greater in the single film structure. If there was no condensate, single layers transmitted more direct light, but this was always reversed when conditions were such as to cause condensate on the roof of the greenhouses. Conden-

Table 3: Total direct light intensity in single and double polyethylene covered greenhouses, the latter air-inflated (relative units).

| | Single layer | Double layer air-inflated | Outside | Mean |
|---|---|---|---|---|
| Condensate on film | 218 | 325 | 613 | 385 |
| Little or no condensate | 615 | 509 | 809 | 644 |
| Mean | 416 | 417 | 710 | |

| | | |
|---|---|---|
| Differences required for significance: | Between individual treatments | 177 |
| | Between single, double layers, and outside means | 138 |
| | Between condensate conditions means | 115 |

sate caused a 40% reduction in direct light over the situation when there was little or no condensate. Thus, though condensate on a greenhouse roof will reduce infrared heat transmission, it is probable that the reduction in direct light is more important in terms of return to the grower.

While these conditions are not strictly applicable to Colorado, the information helps us understand behavior of poly covered greenhouses, and emphasizes that condensate on the roof is an important factor in determining direct light transmission.