COLORADO FLOWER GROWERS ASSOCIATION, INC.

IN COOPERATION WITH COLORADO STATE UNIVERSITY

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Water Loss from Carnations Grown under Fiberglass

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A previous bulletin (#233) examined water loss from carnations grown under glass and in inert media. The results showed a close correlation between total outside solar radiation and water loss, and the rate of water loss directly influences stress in carnations. Similar measurements were conducted in a fiberglass greenhouse the following year. The relationships between stress and water loss were similar. But, the mean daily water loss was less at high light intensities, the differences becoming less as solar radiation decreased. The effect, however, resulted in an estimated 27% decrease in water consumption by carnations grown under fiberglass. But, if the environment was not adequately controlled, rate of water loss from carnations under fiberglass could equal the maximum rates found for carnations grown under glass.

Methods

Three weighable lysimeters were moved to a central north-south bench, in a north-south, fiberglass covered greenhouse in the summer of 1968. One lysimeter was located in the center of the bench, the other two at either end. The entire bench, including plots, was filled with an inert medium and planted to carnations, the variety White Pikes Peak in, and adjacent to, the weighable plots in July 1968. Instruments for measuring radiation inside the greenhouse were located to 10 to 20 inches below the west roof. Wet and dry bulb temperatures were determined at three different heights above the center plot, at either end of the bench, using aspirated shelters, and dry bulb temperatures outside the greenhouse and just inside the evaporative pad. An infrared thermometer was focused on the top of the bench for continuously recording the mean plant temperature.

Sufficient CO_2 was added from natural gas burners to maintain levels in excess of 500 ppm whenever the exhaust fans were off. Some air circulation was maintained within the house by operating the fan motors on two of the horizontally mounted, natural gas heating units. Evaporative pad operation occurred whenever the outside air temperature was sufficiently high to prevent freezing at a low wet bulb temperature. This humidified air, at initial cooling stages, was distributed through a polyethylene tube extending the length of the house. As more cooling was required, adjustable louvers located between the greenhouse and evaporative pad began to open, admitting greater volumes of humidified air. Heating was from overhead, natural gas burners, blowing horizontally in one direction on one side of the greenhouse, in the other direction on the opposite side.

On selected days, during each month beginning October 1968, through May 1969, data on temperatures, radiation and water loss from the weighable lysimeters were recorded at 10-minute intervals. These data were subjected to moving means, smoothing operation, using five values for each lysimeter record, three values for each temperature and radiation measurement. The vapor pressure of water in air at each temperature was determined using a standard psychrometric equation, and the relative humidity calculated. The vapor pressure gradient between carnation and air was calculated by assuming that the internal spaces of the leaves were saturated at the measured plant temperature.

Results

In general, the high humidities maintained by the control system, in conjunction with lower radiation under fiberglass, resulted in an approximate 27% reduction in consumptive water utilization over that found for carnations in inert media under glass. Assuming a 25% waste, consumptive water utilization for carnations in inert media under glass was calculated at 8.3 acre-feet per year, whereas that for carnations in similar substrates under fiberglass was 6.0 acre-feet per year - or about two million gallons.

The relationship between mean daily water loss and total outside solar radiation was computed and compared with the curve obtained for water loss under glass in Fig. 1. The higher the total outside short wave radiation, the greater the difference between glass and fiberglass. At low light levels, the differences were probably not significant. In both instances, the relationships likely overestimate water loss during the summer. During the winter, a considerable portion of the energy for evaporating water comes from the heating system.

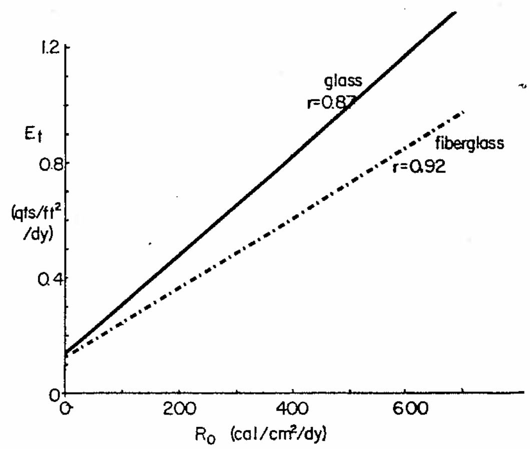

Fig. 1. Relationship of water loss (E_t) to total outside, short wave radiation for carnations grown in a fiberglass covered greenhouse and in a glass covered greenhouse.

Stress measurements were also made under fiberglass. The differences between stress in the fiberglass and glass houses, as a function of water loss, were not remarkable (Fig. 2). According to Fig. 1, an outside solar radiation level of 600 gm-cal/cm^2/day would result in a water loss rate of about 0.8 quarts per square foot per day in the fiberglass house, and a rate of nearly 1.2 qt/ft^2/day in the glass house. This would mean, from Fig. 2, that stress in carnations under fiberglass would be about 170 psi as contrasted to nearly 220 psi in a glass greenhouse. This would appear to be a significant reduction in internal plant stress, with the result that, all other factors being equal, an increase in carnation growth rate would be expected. As radiation level decreased, however, these differences would disappear. In a northern, cloudy, climatic regime, there likely would be no benefit in the use of fiberglass covers versus glass greenhouses, insofar as stress in the carnation is concerned.

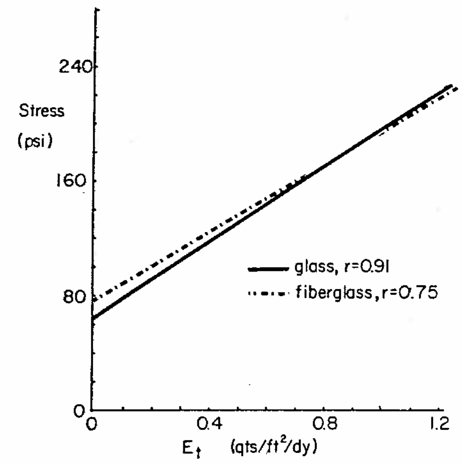

Fig. 2. Relationship between stress in the carnation and water loss in fiberglass and glass covered greenhouses.

The method of temperature control in the fiberglass greenhouse, however, resulted in greater temperature variability under certain conditions. Despite high relative humidities, water loss from carnations could equal water loss from carnations under glass. Fig. 3 compares water loss, stress, vapor pressure gradient and relative humidity for two comparable days in glass and fiberglass greenhouses. The solar radiation regimes during the days were similar. The reason for excessive water loss under fiberglass was attributed to excessive plant temperature above air temperature as the result of insufficient air movement. Therefore, the vapor pressure gradient between the leaves and the air reached relatively high levels, and this is the determining factor - not relative humidity - in regulating water loss from plants. It is only when plant temperature is relatively close to air temperature that relative humidity can be used as indication of the demand for water placed upon a plant by the environment. In addition, carnations grown under fiberglass, with minimum water stress, will likely lose more water for a given vapor pressure gradient due to lower resistance in the leaves (CFGA Bulletin 233). As changes are made in the environment to increase growth, control becomes more critical with fewer allowable mistakes. The relationships between good environment and the necessity for fewer mistakes are not often considered when an innovation is made. There should be an appreciation of the fact that a new practice or new equipment places greater responsibility on the individual, with consequences resulting from mismanagement proportionally larger.

Under winter conditions, a portion of the energy used to heat the greenhouse is applied to evaporating water. In Fig. 4, the ratio between net radiation (R_n) and water loss (E_t) is given for selected days for fiberglass (upper) and glass (lower). At a ratio of 1.0, the energy used to evaporate water from the carnation is exactly equal to the available net radiation. A higher ratio means that energy is coming from some other source in addition to net radiation. Not until outside radiation becomes high, with moderate outdoor temperatures, does net radiation begin to exceed energy used in evaporating water from the carnation in greenhouses. Under those circumstances, the additional energy that would normally be used to heat the plant, further increasing water loss, is removed by the evaporative pad cooling system, tending to maintain the ratio of E_t/R_n less than one.

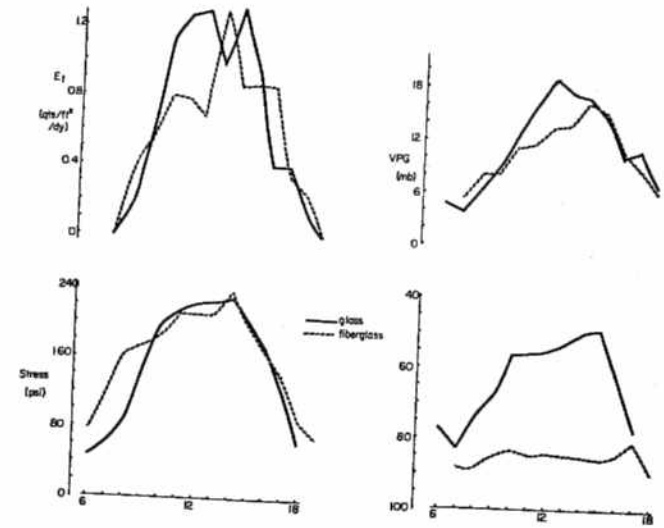

Fig. 3. Various comparisons of environmental factors in glass and fiberglass covered greenhouses on days having similar outside radiation levels. Upper left: rate of water loss expressed as quarts per square foot of bench area per day. Lower left: Negative pressure in the carnation stem. Upper right: Vapor pressure gradient (VPG) in millibars pressure between water vapor pressure in the carnation leaf and in the air outside the leaf. Lower right: Relative humidity in glass and fiberglass greenhouses for comparable days.

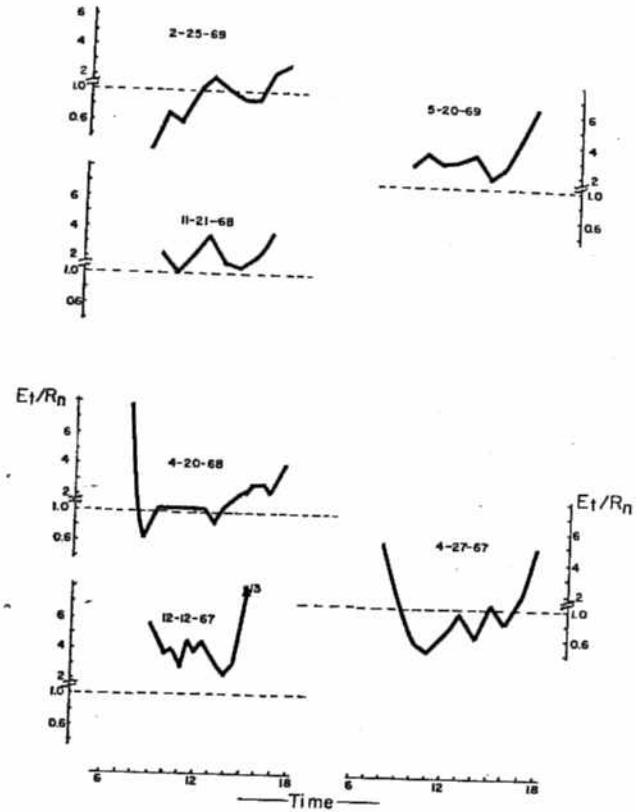

Fig. 4. Variation in the ratio of water loss (E_t) to net radiation (R_n) during selected days in a fiberglass greenhouse (upper) and in a glass greenhouse (lower).