Carnation stomates -- Comparisons between glass and fiberglass

Joe J. Hanan

It appears that reduced stress is one of the reasons for improved carnation growth under clear fiberglass in Colorado. Experiments (Holley and Bennett, CFGA Bul. 148) and several years' experience with clear fiberglass have shown that carnation yield and quality are usually better than when grown in glass-covered houses in Colorado's high sunlight—despite the fact that total solar radiation in fiberglass houses is usually less (Goldsberry, CFGA Bul. 213). While the fact is known, the reasons "why" have never been adequately demonstrated. If research is to be conducted with minimum cost and maximum efficiency, for maximum return to the producer, it is occasionally necessary to find the "why" that will allow intelligent decisions in the future.

Carnation stomatal behavior under different conditions is important since the stomates play a primary role in water loss and CO_2 uptake. The opening of the pore determines to a large degree the rate of water loss as well as CO_2 uptake for food production. It is generally agreed that light is the trigger for initial stomate opening. As light is absorbed by the leaf, CO_2 concentration inside the leaf is reduced, resulting in stomatal opening. As the radiation intensity increases, the stomates open wider, reducing the resistance to CO_2 diffusion into the leaf as well as the resistance to water vapor movement out of the leaf. However, the effect of stomatal pore resistance on CO_2 diffusion is usually considered to be less than the effect on water loss. As radiation increases, and water loss increases, the stomates continue to open. But, the water loss results in a negative pressure within the plant to pull the water from the root medium, through the plant, to the leaves and hence into the air. If the suction is great enough—either due to dry soil or high water demand—the stomates begin to close and the carnation wilts.

Increasing the external CO_2 concentration has a tendency to close the stomates. As long as CO_2 levels are not high enough to close the pores completely, it might be expected that benefits of increased yield from CO_2 injection could result from reduced stress (lower water loss) as well as more food production. If the stomates can be made to open wider without increasing stress to levels where growth begins to decrease significantly, it seems logical to expect better CO_2 uptake—provided there is sufficient solar energy to drive the photosynthetic process at its maximum rate.

Procedure

During 1967-68, the leaf cup hygrometer (CFGA Bul. 214) was employed on carnations grown in inert media in a glass-covered house in order to determine the resistance of the leaf to water loss. Six fully expanded leaves on the upper portion of stems were tagged and measured with the leaf cup. Immediately afterwards, stomatal impressions were obtained with silicone rubber. For each leaf impression, the width of ten pores was measured. While the silicone rubber was curing, the stems were cut and placed in a chamber for the purpose of determining stress in the plant. Fig. 1 shows the chamber with the cut stem passing through the lid and exposed to the air. After sealing, the pressure was steadily increased until water began to bubble from the cut surface. The pressure necessary to force water from the stem could be considered as a measure of the negative pressure to which the stem was being subjected as the result of differences in water supply and loss. The series of measurements were made at various times during the daylight hours, usually near noon. The same procedure was followed during 1968-69 on carnations grown in inert media in a clear fiberglass-covered house.

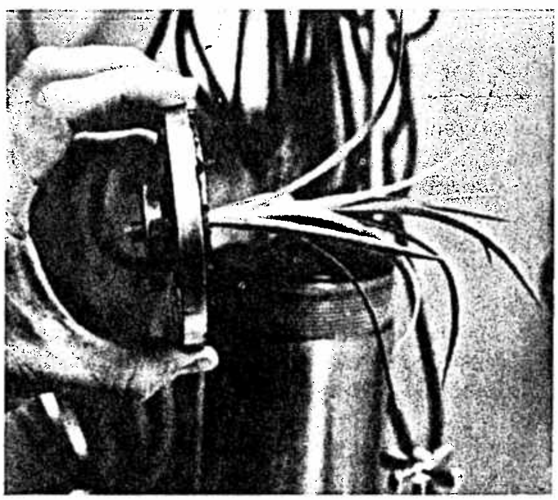

Fig. 1. Pressure chamber for determining internal hydrostatic pressure in the carnation.

Results

The relationships between width of carnation stomates, stress and resistance to water loss are shown in Fig. 2. The upper curves show that as the stomates began to open, internal negative pressure increased slowly. But, as the pores continued to open, the stress increased at a faster rate in the glass house as compared to the situation in the fiberglass house. The correlations for both of these curves exceeded 0.90. For a given width of pore, the stress to which the carnation was being subjected was less under fiberglass than under glass. For example, a width of 4 microns (μ) resulted in a stress of 120 psi under fiberglass as compared to approximately 160 psi under glass. Assuming all other conditions equal, growth should occur at a faster rate under fiberglass as compared to glass.

These results might appear contradictory since in Fig. 2 - lower, the resistance to water loss (expressed as the time in seconds required for vapor to move one centimeter, sec cm^{-1}) was less at all stomatal widths under fiberglass as compared to glass. Therefore, a higher rate of water loss would be expected, hence higher stress. But, a logical explanation results from the probable lower solar radiation under fiberglass, therefore a reduced rate of water loss. Apparently, the reduced solar energy, perhaps coupled with a better light distribution, does not significantly reduce food production. If the resistance to vapor diffusion is considered similar to the resistance to CO_2 diffusion, then the lower resistance under fiberglass would enhance CO_2 uptake. This may also offset a lower radiation level.

Another contradiction to both sets of curves is the fact that carnation leaves grown under glass will usually have a greater number of stomates per unit area (CFGA Bul. 214). However, what happens is that the individual cells become smaller as the plant is hardened so that the total number of pores per plant probably does not change significantly. More important, the pores are smaller and more deeply sunken into the surface of the leaf. Total resistance to vapor flow is increased under glass as the result of a continually higher stress.

These results point up the complexity of interactions between environment, the carnation and yield, and the fact that we really know very little. The probable reasons for improved yield under clear fiberglass in Colorado can be assigned, for the present, to reduced stress and improved CO_2 uptake.

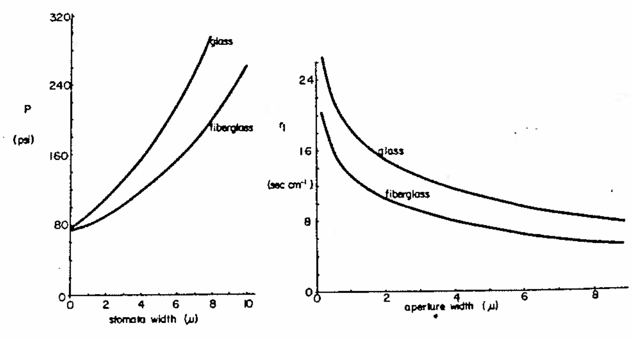

Fig. 2. The effect of stomate width under clear fiberglass and glass on resistance to water vapor diffusion (r_1, lower) and on stress (upper). The lowest correlation was 0.80, the highest 0.94; the curves are significantly different from each other.