TOWARD MANAGEMENT OF PLANT-WATER RELATIONS

Robert P. Doss, Assistant Specialist, Department of Environmental Horticulture, University of California, Davis,
and Thomas G. Byrne, Specialist, Floriculture Research Facility, Deciduous Fruit Field Station, San Jose

The next major step towards increasing greenhouse production could well be effective management of plant-water relations. A plant's internal water balance, or degree of moisture stress, can be described as its water potential. A plant growing under stress has a low water potential. As stress is reduced, the plant water potential increases. And there now seems to be no question that, all other things being equal, plants grow best when the optimum water potential is maintained. The real catch is the qualification "all other things being equal," since it's pretty difficult to increase water potential without adversely affecting other factors that influence plant growth.

Some of the problems are pointed up by research done during the past year at the San Jose Floriculture Research Facility of the Department of Environmental Horticulture. Usually the results of such research don't get published; they wind up in the file marked "lousy idea — not worth talking about!" and are forgotten. These particular results, however, do illustrate some of the dilemmas we've faced in trying to find ways to increase growth through management of plant water potential. And they may also provide some insights into certain aspects of good horticultural practice.

We indicated in an earlier article that frequent irrigation can increase plant growth (Doss, Byrne, and Kretchun 1975). What was not said was that *very* frequent irrigation can have the opposite effect. The problem, of course, is soil aeration. Roots, like most other living organisms, need oxygen to survive and grow. Too frequent irrigation can limit available soil oxygen to levels that inhibit root growth. Such was the case for the mum plants whose weekly growth is graphed in figure 1. Growth increased as the irrigation frequency was increased up to once a day. A greater frequency limited soil aeration and resulted in less growth. The drainage characteristics (porosity) of the soil play a large part in the response to watering frequency. So, too, do the size of the plant and the prevailing weather conditions. During the week after the data shown in figure 1 were taken, the most frequently irrigated plants grew the most. This was because the plants were larger and there was more bright sunny weather.

Bright, sunny weather can also *cause* problems by increasing the transpiration rate so that the plant loses water faster than the roots take it up. The result is a decreased growth rate, even though the wilting point may not have been reached.

Treatments that reduce transpiration should increase plant water potential and allow more growth. One way to reduce transpiration is to close the stomates (pores) of the plant. And one way to close stomates is to increase the carbon dioxide (CO_2) concentration in the air. The logical deduction is that increasing the CO_2 level in the daytime to a point where stomates close will increase growth. Such was not the case in the experiment shown in figure 2. In fact, the CO_2-treated plants actually grew less than the untreated plants. The CO_2 concentration used in this experiment may have been so high that the stomates closed to the point of inhibiting photosynthesis. Or it may be that high CO_2 levels inhibit some other processes necessary for growth.

If CO_2 doesn't work, then how about blackclothing to increase water potential by decreasing transpiration? Stomates close at night. Would it be possible to put the plant in darkness for a short time during the day and thus close the stomates long enough to benefit

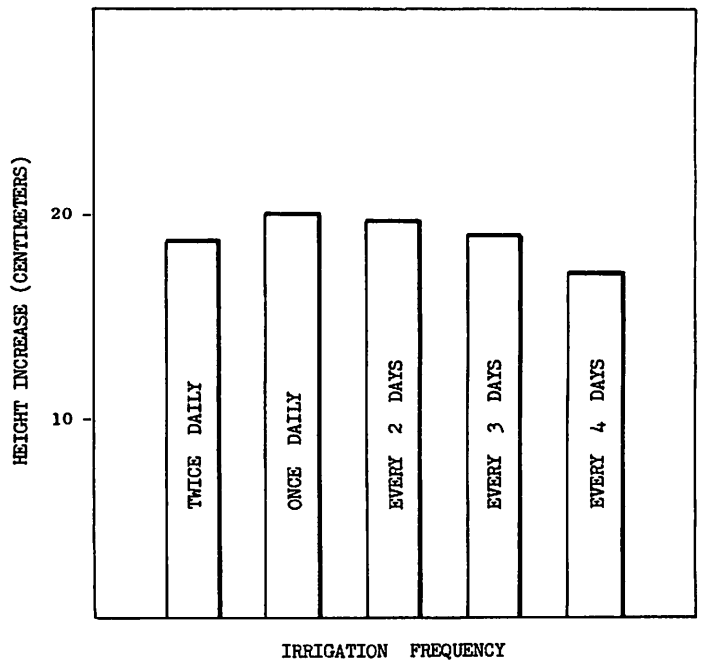

Fig. 1. The influence of irrigation frequency on growth. Height increases represent stem growth during 1 week. Values are for 12 plants per treatment. *Chrysanthemum morifolium* 'Polaris' plants were grown in February to obtain this and all other data presented in this paper. The plants were provided by California-Florida Plant Corp., Fremont.

growth? Apparently yes, since it was determined that water loss is decreased and water potential increased by giving plants a half-hour dark period in the middle of the day (fig. 3). However, photosynthesis requires light, and the plants given the mid-day blackcloth treatment didn't grow as well as those left in the light. It's possible, though, that a shorter dark period would give better results. The darkened plants did show increased water potential and decreased water use for a considerable time after being returned to full sunlight.

Misting is another way to increase water potential (fig. 4). Again, there are problems, because misting can also cause such undesirable effects as excessive cooling or leaching. Plants must be fairly large and the days brightly sunny for misting to improve growth. Misted mum plants grew less than unmisted plants until they were 4 weeks old (fig. 5). Thereafter, plants misted at 1- and 2-hour intervals from the time they were planted as rooted cuttings had greater growth rates than those not misted. The table gives the average height of these plants measured at weekly intervals from the time they were planted until they were 5 weeks old. Misting at 1- or 2-hour intervals, beginning on the day of planting, resulted in taller plants after 4 weeks. Height differences could be greater if the misting were begun when the plants were older. They could also be greater during the summer when days are longer and sunlight more intense.

The ideal practice for proper management of plant-water relations in the greenhouse will be one in which water potential is increased without growth-inhibiting side effects. We haven't found it yet, but we're still looking!

LITERATURE CITED

Doss, R. P., Byrne, T. G., and Kretchun, T. M.
1975. Reduce water stress — a formula for increased plant growth. *Florists' Review* 156(4044):21-22 (June 5).

CUMULATIVE GROWTH OF CHRYSANTHEMUMS AS INFLUENCED BY FREQUENCY OF MISTING

Misting frequency (min.)	Height (cm) as measured each week from planting					
	0	1	2	3	4	5
15	6.6	12.7	26.9	46.5	66.0	85.4
30	6.6	12.5	27.4	47.3	67.3	86.3
60	7.9	12.8	27.9	47.8	67.7	87.9
120	7.0	12.8	27.9	48.0	67.7	87.8
no misting	7.2	13.4	28.7	49.1	66.9	86.2

Note: Data shown are for the same plants whose growth rates are graphed in figure 5.

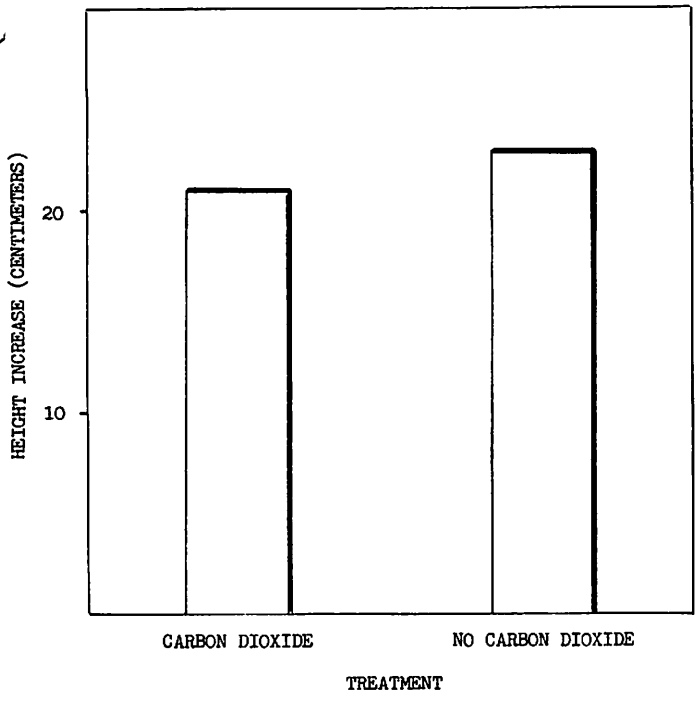

Fig. 2. The influence of high carbon dioxide concentrations on growth. Chrysanthemum plants were placed in two similar, clear, open-topped, polyethylene chambers. Carbon dioxide gas was introduced into one chamber until a flame at plant height was extinguished. This was done at 10:00 a.m., 12:00 m., and 2:00 p.m. daily. Height increases were measured over a 1-week interval. Values are averages for nine plants per treatment.

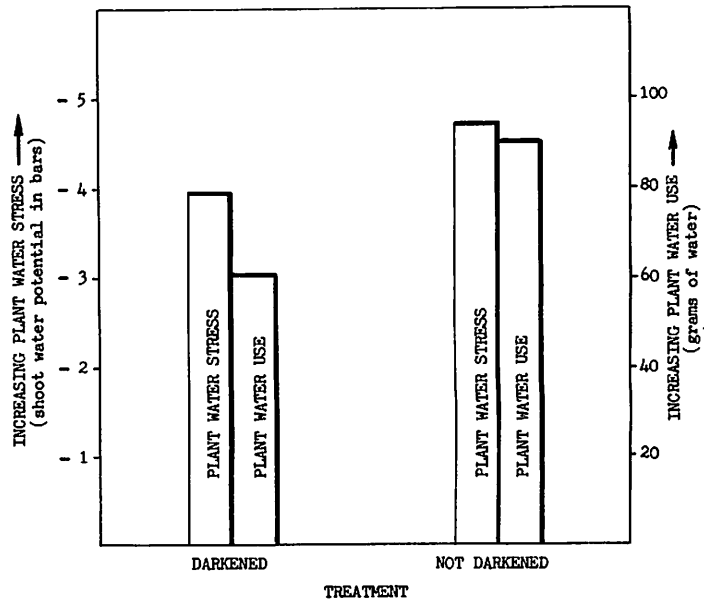

Fig. 3. The influence of a short, mid-day dark period on plant water stress (as measured by plant water potential) and plant use of water. The "darkened" chrysanthemum plants were placed in an aluminum-foil-covered chamber from 12:45 p.m. to 1:15 p.m. daily. Water use was measured from 12:15 p.m. until 2:15 p.m., and water potential was measured at 1:15 p.m. Water-use values are the averages of three pots, each containing three plants. Water potential values are averages for three plants.

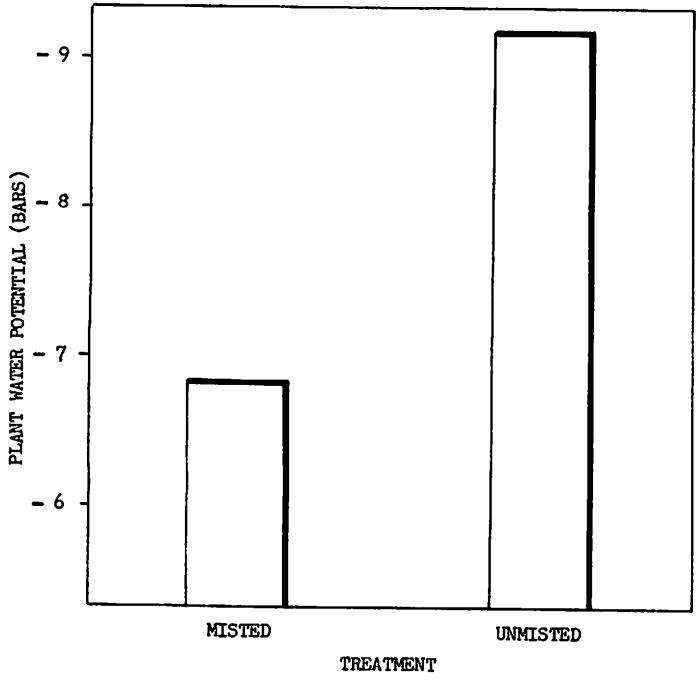

Fig. 4. The influence of misting on plant water potential (a measure of plant water stress). Chrysanthemum plants were misted at 30-minute intervals beginning at 10:00 a.m. and ending at 3:00 p.m. daily. Each vertical bar represents the average of four measurements made at 1:00 p.m. on a sunny day in February. Note that a higher water potential is indicated by a lower negative number.

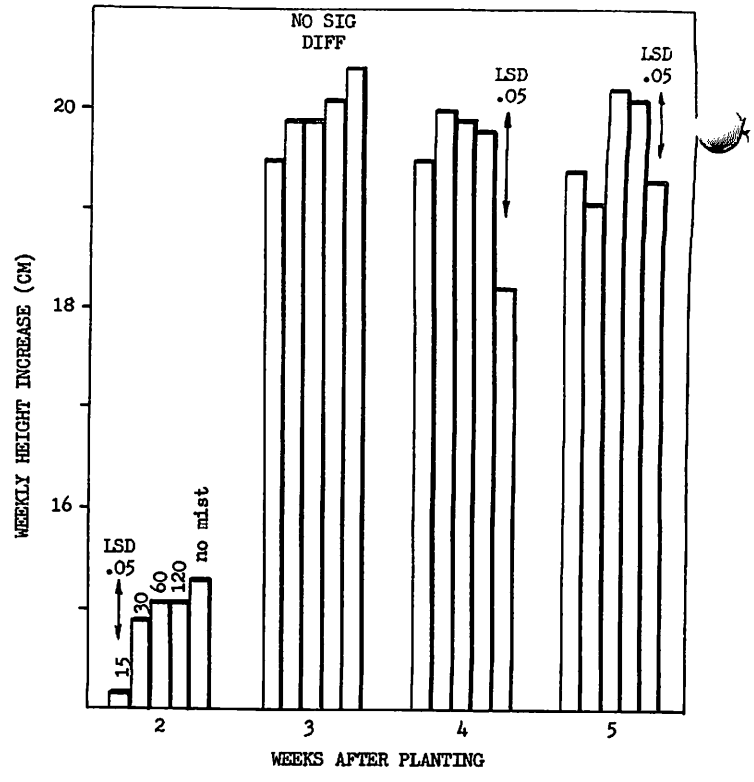

Fig. 5. The influence of misting on plant growth. Chrysanthemum plants were misted daily at intervals of 15, 30, 60, and 120 minutes from 10:00 a.m. until 3:00 p.m. The intervals are shown above the bars representing the second week of growth. Note that, as the plants became taller (larger), misting began to have a positive effect on their growth. Each bar represents average measurements for 12 plants. The least significant differences among the values for each week are indicated by the arrow-tipped line segments.