Colorado Flower Growers Association, Inc.

IN COOPERATION WITH COLORADO STATE UNIVERSITY
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Water Utilization by Carnations

Effect of three irrigation regimes on growth and flowering

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With funds provided by the Federal Water Pollution Control Administration[1], investigations into the water relationships of carnations were started in 1965. The purposes of the investigations are to determine the relationships between water utilization, the environment and growth. Of particular interest is the efficiency of water use, the effect of environmental factors on internal water stress, and methods whereby stress and water use may be predicted and controlled.

Colorado has one of the best environments in the nation for maximum yield - provided water is freely available. However, the state is arid, and there have been numerous predictions regarding the implications of future water shortages on the economy. Aside from the immediate practical applications of this investigation, the study has a long range view in mind in maintaining the greenhouse industry's economic advantage in the use of a raw material; and the compilation of basic data that may be applied as we improve the greenhouse environment for maximum production.

This article reports on the first results obtained in evaluating response of carnations to variations in irrigation frequency in a soil substrate, and a rough approximation of the water utilized. A preliminary report was given in CFGA Bulletin 194.

[1]Grant No. WP00870, Department of Interior.

Methods and Materials

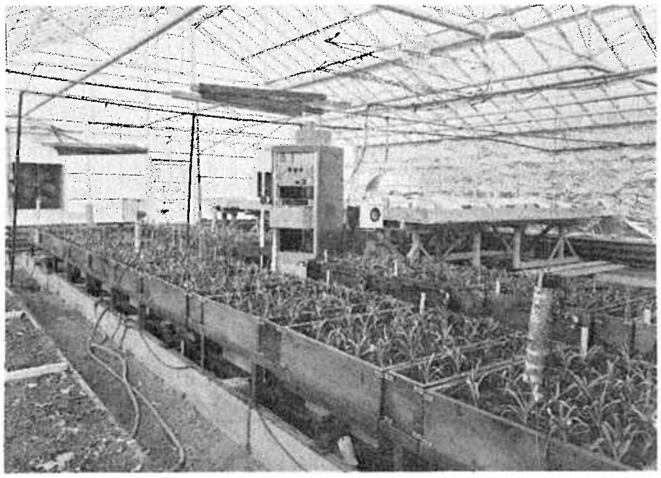

Figure 1: General view of the experimental area, showing lysimeter plots and buffers.

Figure 1 is a general perspective of the experimental area. A total of 18 plots (lysimeters) were arranged linearly on 2 benches, with buffer plots between each lysimeter. Each plot has a steel container below it so that water lost by drainage can be measured. Water applied to the soil surface by a modified Chapin system was metered, so by subtraction, the water available for plant use and evaporation could be measured.

Irrigation treatments were selected to bracket the extremes. Five plots were watered when soil suction, as measured with a porous cup tensiometer, reached 4 (wet), 5 plots when suction reached 60 (medium), and 5 when electrical resistance as measured with a gypsum block reached 10 kilohms (dry). Porous cup tensiometers are usually limited to values less than 70 at this altitude, and 10 kilohms represented the maximum value on a resistance bridge meter, and would be considered "dry" whether in the field or greenhouse. Irrigation continued until the plot began to drain.

The soil consisted of a 1-1-1 mixture of Fort Collins loam, leaf mold and sand, 5 inches deep in the plot. Cultured cuttings, White Pike's Peak, were benched, 24 plants per plot, on November 24, 1965, given a single pinch, and the experiment terminated August 26, 1966. General cultural procedures were followed with nutrients injected into the water line at each irrigation.

Records included yield, quality (mean grade), keeping life, fresh and dry weights, dye uptake, leaf width, internode length, the number of leaf pairs on a standard-grade stem, and the amount of water applied, lost and retained in each plot.

Results

Table 1: Effects of 3 irrigation treatments for 9 months on growth and flowering of carnations.

Measurement	Treatment			HSD[1]
	Wet	Medium	Dry	(5%)
Yield				
Total	1335	1067	858	76
Per ft^2 (9 mos.)	37.8	30.2	24.3	
Mean grade	4.27	3.97	3.71	0.10
Mean fresh weight per standard grade flower (g)	19.9	19.5	19.1	0.4
Mean dry weight per standard grade flower (g)	3.81	3.91	3.81	0.02
Per cent dry weight	19.1	20.1	19.9	--
Leaf width (mm)	11.9	11.8	11.0	0.1
Internode length (cm)	11.3	10.1	9.9	0.6
Number of leaf pairs per standard grade flower	6	6	6	--
Keeping life (days)	6.4	6.8	7.2	0.5
Stem strength (degrees of bending from the horizontal)	8.7	8.7	8.9	--

[1] HSD: Honestly significant difference -- the value required for differences to be statistically significant.

Plant Response - Table 1 is a general summary of the effects of irrigation treatment on growth. Even though plants in the wet treatment in December showed signs of yellowing from overwatering, it was not sufficient to reduce total yield. The wet treatment was highest in yield and grade. Grade throughout the flowering period was consistent for each treatment, (Fig. 2). The greatest increase in yield of the wet treatment came during the second crop (Fig. 3), which peaked earlier and cut off sooner than the other 2 treatments.

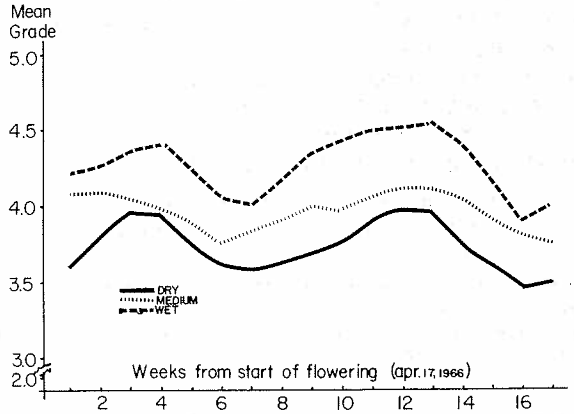

Figure 2: Three week moving mean of weekly mean grade for three different irrigation regimes in a soil medium.

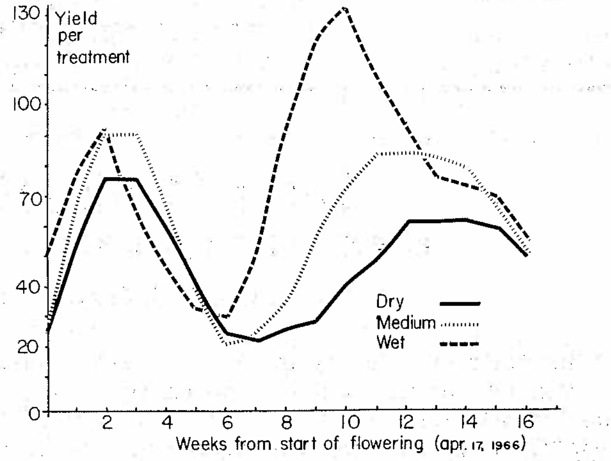

Figure 3: Three week moving mean of weekly yield of carnations subjected to three irrigation treatments.

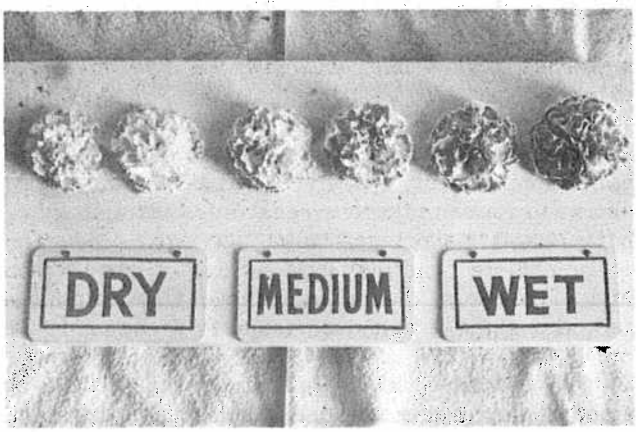

Figure 4: Effect of irrigation treatment on dye uptake in carnation cut flowers.

Keeping life in the wet plots was reduced slightly (Table 1), but the dye uptake by flowers in the same irrigation regime was enhanced considerably (Fig. 4). There appeared to be little effect on percent dry weight even though fresh and dry weights were significantly different. Increasing the frequency of watering had the effect of stretching the internodes, but did not have a significant effect on stem strength.

Table 2 shows the percent of each grade produced in each treatment, while Table 3 compares the percentage of each grade on the basis of total flowers produced from the three treatments combined. By far the greatest number of fancies and standards was produced in the wet treatment, with few fancies contributed by the medium and dry plots.

Table 2: Percent of each grade produced by carnations subjected to three irrigation treatments.

Treatment[1]	Fancy	Standard	Short	Design
1. Dry	4.5	71.1	21.5	2.9
2. Medium	10.6	78.4	9.8	1.2
3. Wet	40.1	53.7	5.5	0.7

[1]Treatments consisting of watering carnations when suction reached 40cm water, 600cm water suction and 10 kilohms resistance when measured with a gypsum block.

Table 3: Percent of each grade produced by each treatment in a total production of 3260 flowers from all three treatments.

Treatment	Fancy	Standard	Short	Design
Dry	1.2	18.7	5.6	0.8
Medium	3.5	25.7	3.2	0.3
Wet	16.4	22.0	2.3	0.3

[1]Treatments consisted of watering carnations when soil suction reached 40cm water, 600cm water, and 10 kilohms resistance as measured with a gypsum block.

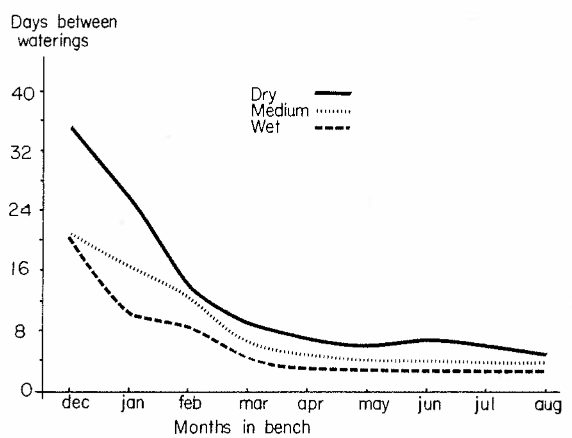

Figure 5: Mean monthly irrigation intervals on carnations subjected to three irrigation regimes.

Irrigation interval - The mean number of days between irrigations is shown in Figure 5. During initial stages of growth, under low light conditions of December, the interval varied between 20 and 30 days. As the plants grew, and as light intensity increased, the amount of water required also increased, resulting in gradually shorter watering intervals. During the period between April and August, differences between irrigation intervals were small. By that time, the plants had been conditioned to the treatment, and as the result of differences in total leaf area (less under the dry regimes), the differences in irrigation interval and water usage could be partially explained. There did not appear to be marked differences in interval from April to August even though light intensity continued to increase and there was a considerable variation in water applied to the plots (Fig. 6).

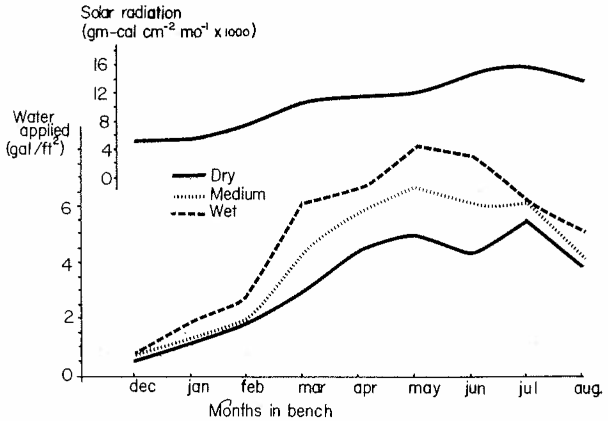

Figure 6: Water applied per month to plots of carnations subjected to three irrigation regimes and compared with total monthly solar radiation.

Water use - Figure 6 compares the amount of water applied per square foot per month for each treatment with solar radiation. Radiation increased in July approximately 4 times over that received in December. However, the amount of water applied, particularly to wet plots, began to decline in May. This indicated that the removal of flowers was effectively reducing the size of the plant, thereby reducing the amount of water applied to the plot.

Table 4: Water utilization by carnations subjected to 3 irrigation regimes for 9 months.

Measurement	Treatment[1] Wet	Medium	Dry	HSD[2] (5%)
Mean number of irrigations per plot	65	43	32	9
Water applied per ft^2 (gal) 9 months	45.4	37.6	29.6	10.8
Water retained per ft^2 (gal) 9 months	32.4	27.4	21.4	2.6
Water lost per ft^2 (gal) 9 months	13.0	10.2	8.2	1.9
Mean volume of water applied per ft^2 per application (quarts)	2.8	3.5	3.7	
Amount of water applied to plot per flower (gal)	1.2	1.2	1.2	
Amount of water retained in plot per flower (gal)	0.9	0.9	0.9	

[1] Carnations watered when suction reached 40cm water, 600cm water and 10 kilohms as measured with a gypsum block.

[2] Tukey's honestly significant difference.

Even though there was a 10 day difference in irrigation interval in December, the difference in amount of water applied during that month was only 0.2 gallons per square foot (less than one quart). Thus, the amounts of water involved during initial stages of growth was insignificant, but the effect on growth was considerable.

Table 4 indicates the number of irrigations per treatment for the 9 month period the plants were in the plots, and the amounts of water applied to the soil surfaces, the amount retained in the soil for plant use, and that lost through drainage. The mean volume of water applied per application varied between 2.8 and 3.7 quarts per square foot, depending upon how dry the plots were at the time of irrigation. The difference was less than one quart. Remarkably, the amount of water used per flower, applied or retained in the plot, did not vary with the treatment. As yield increased, the amount of water necessary to obtain that yield increased in direct proportion. Any efficiency that is to be gained can only come through reducing the loss in drainage or evaporation.

Table 5. Water cost in carnation flower production for 9 months, assuming 20¢ per 1000 gallons.[1]

Item	10,000 ft.^{2} growing area	one acre growing area
Dry		
Total water applied	177,600 gal.	2.38 acre-feet
Cost of water	$35.52	$154.73
Total flower yield	145,800	634,800
Cost per flower	$0.00024	$0.00024
Medium		
Total water applied	225,600 gal.	3.02 acre-feet
Cost of water	$45.12	$196.54
Total flower yield	181,200	789,600
Cost per flower	$0.00025	$0.00025
Wet		
Total water applied	272,400 gal.	3.64 acre-feet
Cost of water	$54.48	$237.32
Total flower yield	226,800	987,600
Cost per flower	$0.00024	$0.00024

[1]Figures based on assumption that 60% of area is in producing beds.

Economics

Assuming a flat rate of 20¢ per thousand gallons, the cost of water has been computed on 10,000 square foot and 1 acre growing areas in Table 5. On a per flower basis, the cost of water is practically immaterial, and hardly varies with irrigation treatment. The values are for a 9 month period. It is possible that later work will change these figures. However, Table 5 emphasizes that water is the cheapest raw material employed in growing carnations, as long as it is available. Proper manipulation of watering practices to increase yield results in the highest return commensurate with the cost of the input. The greenhouse industry has an outstanding advantage in competing with industry for available, domestic water supplies.

Summary

On the basis of these results, it can be concluded that it is poor practice in Colorado to deliberately allow plants to run dry, unless the grower has no alternative in overcoming a deficient aeration problem. The great majority of our present soils are seriously limiting the maximum production possible in this area. We are, in effect, not making use of the environment's capabilities. The fact that each grower's soil is different from his neighbor's complicates the use of any general principles for water application.

At present, we are proceeding on the hypothesis that maximum growth will occur when the plant is subjected to the least stress. It is obvious that the root medium must be suitable, and that all other factors must be present in the proper amounts at the proper time. It may be necessary to subject the plant to stress at certain times to avoid undesirable characteristics. But it would be better to do this on the basis of concrete evidence, rather than insufficient knowledge. It would be a mistake for growers to begin watering every day. Other problems would make short work of the crop.

Your editor,

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