Capillary Bench Watering of Pot Plants

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Hand watering of floricultural crops probably became a most important problem for the first time during the war years of the early and middle 1940's. Labor became very scarce; thus much attention and experimentation was turned to "labor-saving methods." Many of our basic ideas for present day methods of automatic watering of floricultural crops evolved from this early work.

The work by Post (11, 12, 13, 14), Seeley (22, 23, 24), and Post and Seeley (15, 16, 17) showed that automatic watering of floricultural crops was possible. They used sub-irrigation on bench crops (11, 13, 15), automatic surface watering of bench crops (18), constant water level subirrigation for pot crops (22, 24), and injection watering of pot crops (11, 15, 24). They showed that automatic watering when compared to hand watering reduced labor without a reduction in plant quality or production (11, 24).

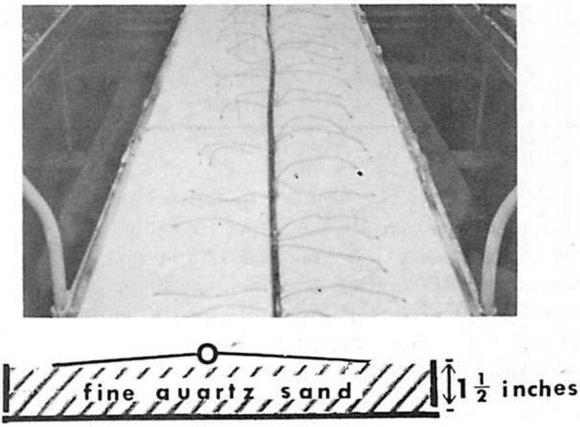

Figure 1. Capillary bench at Cornell as seen from top and in cross section.

As a historical note, sub-irrigation of plants was first suggested by E. C. Green and W. S. Turner in 1890 (6, 7, 8, 9). They attempted to use sub-irrigation to prevent what they called lettuce rot. However, its practical significance for other crops was soon realized and much attention was turned to sub-irrigation during the 1890's (7, 9, 19, 20, 21, 26). The experiments reported in-

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creased yields and accelerated plant growth when using sub-irrigation vs. surface watering (6, 7, 8, 9, 19).

With many of these methods of automatic watering, expensive, water-tight benches were a must. Many growers could not easily convert their benches to sub-irrigation.

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There were also other problems associated with these methods of watering.

Growing practices had to be changed. Fertilizers were not leached from these soils and in some cases there was an accumulation of salts at the soil surface (15). Soil mixes were important as shown by work at Iowa (25) and Michigan (5). Because of these and other problems and with the increased labor force available after the war, the interest in automatic watering declined for a few years.

In the late '50's when labor costs began to rise and with spiraling inflation, the pot plant grower was forced to seek ways of cutting production costs. And again as earlier, automatic watering became important. The introduction of the Chapin or "sphaghetti" watering system was a step toward this end.

The Chapin system is not without problems. There is the hand labor of placing the tube in each pot. Tubes become plugged. The system is fixed in that it is designed for a certain size and number of pots when it is installed. Increasingly the spacing of plants as they grow is difficult. With these and other problems, it seems advantageous to seek other means of automatic watering of pot plants.

Capillary watering of pot plants is not new. Seeley in 1948 suggested capillary watering of pot plants. He called it sub-irrigation using non-water tight benches (24). So, we are taking an old idea and applying modern materials and methods.

Capillary watering as it is commonly called today has received much attention in the European countries (4, 10). Many of the present recommendations have come from these countries (1, 2, 3) . A report has said that one grower in England is using capillary watering for the production of year-round pot mums (27). Personal contact has also pointed to the extensive use of capillary watering in Europe. Bdr. Nielsen outside Copenhagen, Denmark uses capillary watering in the production of 1.3 million 4-inch pot mums a year. They have also successfully grown 300,000 poinsettias with this method of watering.

Capillary watering has not received this attention in the United States mainly because of our brighter, warmer growing conditions. These conditions create greater problems with capillary watering. Thus, we have begun work here at Cornell to study the use of capillary watering under our conditions. The results given are a progress report to inform you, the grower, of what we are doing.

The work with capillary watering began here at Cornell two years ago. The first studies dealt with methods of applying water to the sand, pot type, soil type, and algae control. Results indicated that the Chapin system (Fig. 1) was better than the Gro hose for applying water. The thin-walled plastic pots with four holes for drainage were better than either clay or expanded polystyrene pots. Peat-lite mix allowed for more capillary water movement than the 2 soil, 1 peat, and 1 perlite; or 1 soil, 1 peat, and 1 perlite that was tested. Of the many algacides that were tried, Algamine was the only one that gave any long lasting control. During these studies soluble fertilizer was applied three times a day for one minute via the Chapin system. This method of fertilization presented two major problems: 1) it supported algae growth on the sand. 2) A very high soluble salt build up occurred in the upper one fourth of the soil ball (Fig. 2).

At this point, we decided to concentrate our efforts on the problem of fertilization for the capillary bench. Preliminary experiments indicated that the slow-release fertilizer "Osmocote" may be a better means of fertilization than previously tried methods. The following two experiments have sought to answer this question.

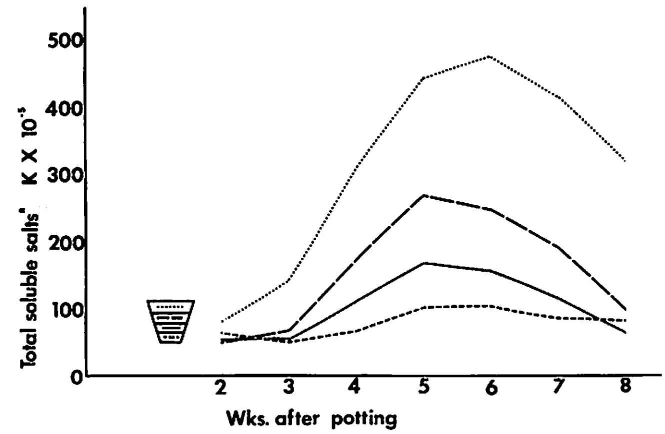

FIGURE 2. Soluble salt readings at four different sampling positions within the soil ball of Golden Yellow Princess Anne mums grown single stem in 3-inch plastic pots on the capillary bench. Fertilized via capillary water with potassium nitrate at 63 ppm nitrogen and 198 ppm potassium for the first 5½ weeks of growth. The plants were in flower eight weeks after potting. Time and position of sampling were very highly significant statistically (Alpha (α) equals .001). Other observations were made and will be reported more fully at a later date.

Experiment I

This experiment was an osmocote rate study. Golden Yellow Princess Anne mums were grown single stem in 4-inch plastic pots. The mum cuttings were potted February 1, 1968 in peat-lite mix of the following proportions: 1 part sphagnum peat moss; 1 part #4 vermiculite; 7 pounds ground limestone per cubic yard of mix[1]; and either 7.5, 10, 12.5, 15 or 17.5 pounds of 14-14-14 osmocote per cubic yard of mix. Each fertilizer level was replicated three times.

The cuttings were potted without drainage in the bottom of the pot. They were watered and then placed on the flooded capillary bench. After being placed on the bench they were again watered from overhead to establish capillarity with the sand. Thereafter, water was applied to the sand on the capillary bench three times a day for one minute (8 am, 12 noon, and 4 pm; E.S.T.). Short days began the day of potting.

Soil samples (in the following root zones: top of pot to ¼, ¼ to ½, ½ to ¾, and ¾ to bottom of pot), foliar samples, fresh weights, dry weights, and height were

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[1] Seven pounds of limestone per cubic yard of mix was used instead of the recommended 5 pounds per cubic yard of mix because earlier experiments with the lower rate of limestone resulted in pH values in the 4.8–5.1 range. This may result from the acidifying effect of the osmocote which is intensified by the lack of leaching on the capillary bench.

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taken five and ten weeks after potting. The plants were in flower ten weeks after potting.

The soil samples were oven dried and carefully screened to remove the osmocote particles before the soil was analyzed.

Results indicated that the amounts of osmocote used resulted in no significant statistical difference among heights of plants (Figure 3). Results of fresh and dry weights are presented in Table 1.

FIGURE 3. Golden Yellow Princess Anne mums grown on the capillary bench at the different rates of osmocote. The photograph was made ten weeks after potting (April 11, 1968).

Table 1. Fresh and dry weights in grams of mum plants at the different osmocote rates. Fresh weight was very highly significant statistically (*a* equals .001) while dry weights showed no statistically significant differences (hsd for fresh weight—65.2 *a* equals .01).

	7.5 lb	.10 lb	12.5 lb	15 lb	17.5 lb
Fresh wgt. in grams	276.8	347.8	377.4	363.5	371.3
Dry wgt. in grams	27.2	30.4	31.7	30.9	31.1

Time of sampling, osmocote rate, and position of sampling were statistically significant for soil nitrates, potassium, pH, and soluble salts. Only osmocote rate and position of sampling were significant for soil phosphorus. There were reductions in all readings with time, increases in nutrient and soluble salt reading with increased osmocote rate, and an increase in nutrient and soluble salt readings as sampling moved from the bottom to the top of the pot. Soil pH on the other hand decreased as sampling moved from the bottom to the top of the pot. Most important was the statistically significant interaction between osmocote rate and position of sampling on soluble salt results as seen in Figure 4. Foliar analysis results are shown in Figure 5 and Table 2.

The results of this study seem to very strongly indicate that osmocote can be used as a source of fertilizer for plants grown on the capillary bench. Not only can we see a rate below which soluble salts remain nearly constant throughout the soil (Figure 4), but there was much reduced algae growth on the sand. This was probably due in part to the lack of nutrients available to support the growth of algae on the sand.

At this point many questions can be raised. The plants were grown single stem in 4-inch pots. Water was applied three times a day. The two most obvious questions to us were: 1) What will the results be with single pinched pot mums grown in 6-inch pots? 2) Will watering frequency

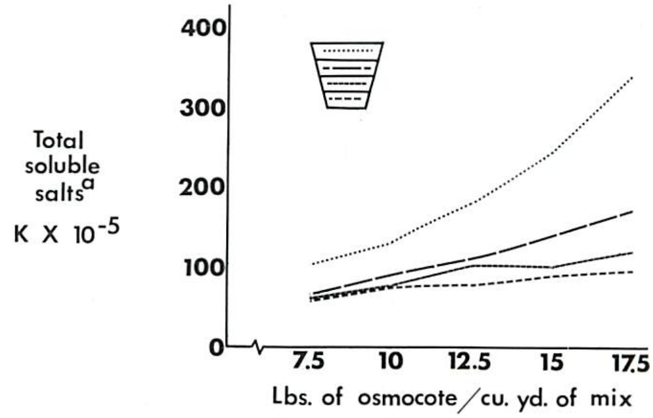

FIGURE 4. Soluble salt readings at the different positions of sampling in the pot versus the rates of osmocote applied. The interaction was significant at *a* equals .001). This tends to say that there are rates of osmocote at which the soluble salt gradient through the pot remains smaller than at the higher rates.

Table 2. The effect of time of sampling on the foliage content of N, P. K, Ca, and Mg of Golden Yellow Princess Anne mums grown on the capillary bench. Contents are expressed as % dry weight.

	5 weeks after potting	10 weeks after potting
nitrogen[a]	5.46%	4.26%
phosphorus[a]	.80%	.61%
potassium[b]	6.19%	6.20%
calcium[a]	1.23%	1.75%
magnesium[b]	.53%	.57%

[a]very highly significant differences between sampling dates (*a* equals .001)
[b]no significant differences between sampling dates

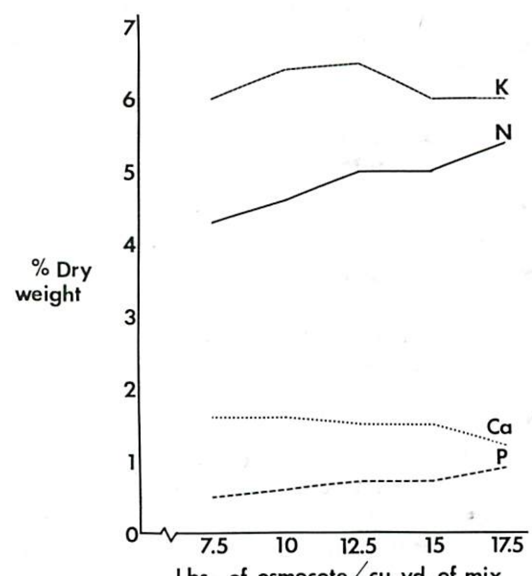

FIGURE 5. Foliar analysis (elements expressed as % dry weight) results of Golden Yellow Princess Anne mums at the five osmocote rates. Osmocote rate was statistically significant (*a* equals .005) for all the elements in the above graph.

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affect the release of nutrients from the osmocote particles? The following experiment sought to answer these questions.

Experiment II

Golden Yellow Princess Anne mums were grown single pinch, four cuttings per pot, in 6-inch plastic azalea pots. The cuttings were potted May 15, 1968 in peat-lite mix of the following proportions: 1 part sphagnum peat moss; 1 part #4 vermiculite; 7 pounds ground limestone per cubic yard of mix; and either 12.5 or 15 pounds of 14-14-14 osmocote per cubic yard of mix. These rates were chosen because previous experiments indicated they were needed for mums grown in 6-inch pots. Also, experiment I showed that these rates produced the largest fresh weight on single stem mums (Table 1) and foliar analysis results indicated these levels of osmocote to be within the proper range for the 4-inch mums (Figure 5).

The cuttings were potted without drainage in the bottom of the pots. They were top watered and then placed on the flooded capillary bench. After being placed on the bench they were again watered from overhead to establish capillarity with the sand. Thereafter, water was applied either three times a day for one minute (8 am, 12 noon, 4 pm, E.D.T.) or eight times a day for thirty seconds (7 am, 9 am, 11 am, 1 pm, 3 pm, 5 pm, 7 pm, 9 pm, E.D.T.). The cuttings were pinched and short days began the day of potting. The experiment was replicated three times.

Data were recorded as outlined in experiment I. They were taken 3½, 7, and 10 weeks after potting.

Neither fertilizer rate nor watering frequency made any statistically significant difference in fresh weights (average of 486 grams), dry weights (average of 55 grams) or heights (average of 38 centimeters) of the mum plants (Figure 6). Averages given are figures at ten weeks after potting.

Soil analysis indicated that watering frequency made no statistically significant differences in soil analysis results except for soil nitrates (Table 3).

Table 3. Soil nitrate levels as effected by watering frequency of the capillary bench. Differences are very highly significant (a equals .001.).

	Soil NO_3[1]
Water applied 3 times a day for 1 minute	114.0
Water applied 8 times a day for 30 seconds	141.5

[1]Expressed as ppm NO_3 in extracting solution

This can probably be explained by the high mobility of nitrates in the soil when compared to the immobility or very low mobility of phosphorus, potassium, calcium, and magnesium. Time, position of sampling, and osmocote rate effects can best and most simply be illustrated by looking at soil soluble salt data (Figures 7 and 8). Note the reduction in soluble salt levels with time. This indicates uptake by the plant and a depletion of the osmocote particles. This would also seem to indicate that we were getting the greatest release of nutrients at a time when the

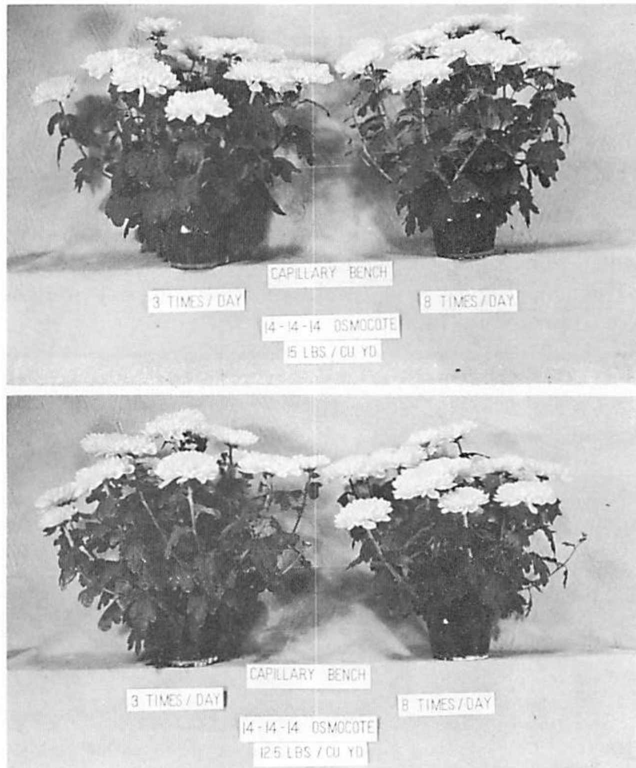

FIGURE 6. Golden Yellow Princess Anne mums grown on the capillary bench. The osmocote rates versus water frequency are shown in the photograph. Photograph was made ten weeks after potting (July 24, 1968).

Table 4. Soil pH at four different root zones. Position of sampling is very highly significant (a equals .001) with respect to soil pH. (hsd equals .39 a equals. 01). equals .01)

	soil pH
top of pot to ¼	5.2
¼ to ½	5.5
½ to ¾	5.9
¾ to bottom of pot	5.9

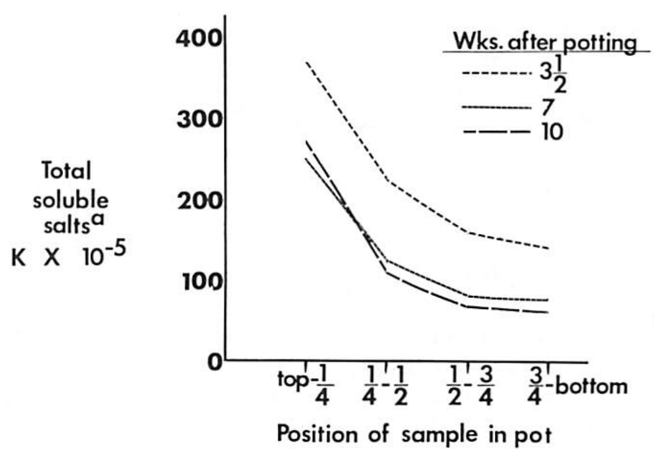

FIGURE 7. Soluble salt readings at the different root zone samples at the three sampling dates. Both position of sampling and time of sampling were very highly significant statistically (a equals .001). .001).

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rate of growth of the plant was the greatest, which should be of value from a nutritional standpoint.

Soil pH varied in the four root zones sampled, with a much lower pH at the top of the pot than at the bottom (Table 4). This could be caused in part by the high pH of the water applied to the capillary bench. The water generally has a pH of above 7.0. The other soil nutrients followed much the same pattern as the soluble salt data presented earlier.

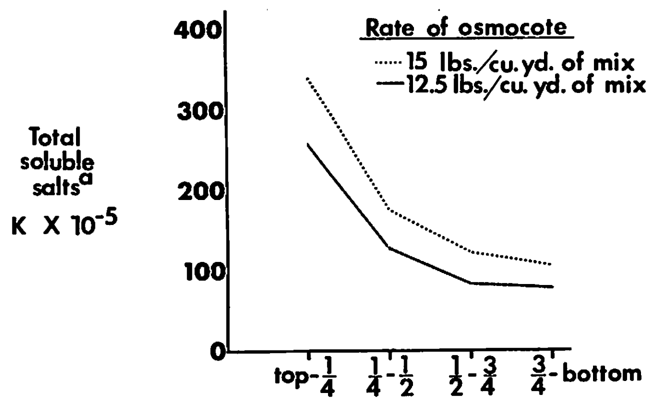

FIGURE 8. Soluble salt readings at the different root zones sampled versus the two osmocote rates. Both position of sampling and osmocote rate were very highly significant statistically (a equals .001).

The two osmocote rates made no statistically significant differences in the foliar content of nitrogen, phosphorus, potassium, calcium, or magnesium. There were statistically significant differences in foliar nitrogen content at the two watering frequencies (Table 5). This follows the soil results presented in Table 3. Time of sampling proved to be statistically significant for all the foliar elements analyzed except potassium (Figure 9).

Table 5. Nitrogen content of the foliage of Golden Yellow Princess Anne mums grown on the capillary bench at two watering frequencies. The differences are very highly significant statistically (*a* equals .001).

	Foliar N[1]
Water applied 3 times a day for 1 minute	4.6
Water applied 8 times a day for 30 seconds	5.0

[1]Expressed as % dry weight

Summary

The information presented here is intended only as a progress report. The two experiments reported are by no means the complete picture of fertilization for the capillary bench. They have shown that capillary bench growing of pot mums is practical. The problem of salt build up can be solved.

We are now turning our attention to ways of predicting when to wet the sand, water movement in the sand and soil, containers suitable for pot plant and bedding plant production using capillary bench watering, and other crops suitable for this type of production.

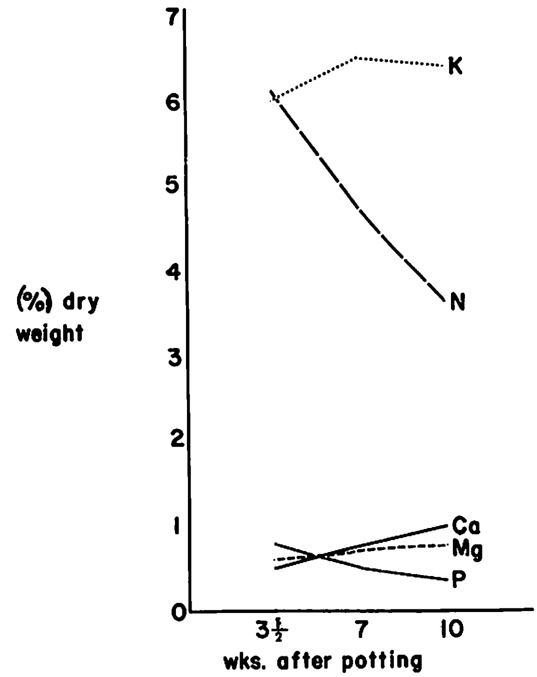

FIGURE 9. Foliar analysis results (expressed as % dry weight) of Golden Yellow Princess Anne mums at the three different sampling dates. Time differences were very highly significant statistically (a equals .001) for all the elements shown except potassium for which time was significant at (a equals .05). The drastic reduction in % nitrogen with times does not follow foliar analysis results reported by others in the pass. However, we got the same results in experiment I (Table 2), so this may be a cultivar difference. It is a question for future experiments to answer.

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