Fluctuating Controlled Water Table Irrigation on Geraniums

J.W. Buxton and J.A. Pfeiffer, Department of Horticulture

Introduction

Improper irrigation significantly limits the growth, quality and profit of commercial container crops. Generally crops are either irrigated too frequently or more likely insufficiently especially under bright, warm conditions. Also, most crops are not irrigated uniformly. The objective of this study was to develop an automatic, no runoff irrigation system that controls and maintains a uniform water/air ratio in the growing media of all containers in a growing area.

The Controlled Water Table irrigation system (CWT) is a modification of capillary mat irrigation used extensively in commercial greenhouses (Figure 1). The vertical placement of the water surface in the trough below the bench determines the air/water ratio in the container growing medium. With the water surface at bench level (0 CWT), the medium holds the maximum amount of water. Lowering the water surface in the trough below the bench decreases the water content and increases the air content in the growing medium. CWT has been used to grow many commercial greenhouse crops in various container sizes (2,3,4,5). Geranium studies are discussed in this report.

Materials and methods

Rooted geranium cuttings were planted in a 15 cm plastic container containing a peat-based growing medium. Peter's Peatlite fertilizer (15N-7P-14K) at the rate of 100 mg N per liter with proportional amounts of other elements as indicated by the fertilizer analysis was used as the fertilizer source. The six plants of each treatment were spaced on 30.5 cm centers in a randomized complete block design with three replications. At the conclusion of the research, geranium tops were cut off at the medium surface, and leaf area and plant dry weight were determined. Data for leaf area are presented here.

Results

At constant CWT the medium air exchange occurs very slowly; therefore CO_2, ethylene, and other gasses accumulate and may become toxic, and O_2 concentration is lowered (1,6). In fluctuating CWT studies, the level of the water surface goes up and down between the two distances below the bench surface. When the water in the trough moves from the high to the low level, the amount of moisture in the growing media decreases and the amount of air increases. Also, the possible toxic gasses in the medium will be flushed out when the water rises and fresh air is moved into the medium when the water goes down.

<u>Constant CWT</u>: Geraniums in 15 cm containers were grown with the CWT set at 0, 2, 4, and 6 cm (Figure 2). Plant growth at CWT 0 and 2 cm was significantly larger than that of those grown at CWT 4 and 6 cm. Roots of plants grown at CWT 0 cm grew mostly in the middle of the container and few reached the bottom, indicating that the water content was too great and the air content too low near the bottom. However, roots of plants at CWT 2 cm were distributed uniformly from the center to the bottom of the container.

<u>Fluctuating CWT and Day/Night Regulation</u>: A day/night regulation of a fluctuating CWT was compared with the constant CWT. The treatments were CWT 2 cm day (D) and night (N), CWT 2 cm D, 2-4 cm D and N, 2-4 cm D. In CWT 2-4 cm treatments, the nutrient solution fluctuated between 2 cm and 4 cm. The CWT table was turned off at 7 p.m. and came on at 7 a.m. The control for the fluctuating system is shown in Figure 3. The CWT treatments did not significantly affect geranium leaf area or dry weight (Figure 4).

Alternating the CWT between 2 and 4 cm appears to have some benefit, and turning the system off at night seems to reduce growth in both the constant and fluctuating CWT compared to being on continuously. However, the variability within the study was large and additional studies are needed to confirm results.

Fluctuating CWT: In this study the treatments were CWT 2 cm, CWT 2-3 cm, CWT 2-4 cm and CWT 1-4 cm. The leaf area of plants grown at a constant CWT of 2 cm, 2-3 cm and 2-4 cm treatments had the same leaf area. However, plants grown at 1-4 cm were significantly smaller than the plants in the other treatments (Figure 5). Apparently, dropping the water table to 4 cm below the bench, even for a short time, reduces growth. Plants grown in constant CWT 4 cm in the previous discussion above also grew poorly (Figure 2.)

Plant Placement from Trough: The first plant in each treatment is 15 cm from the trough, whereas the 6th pot is 165 cm from the trough. While young plants grow at the same rate, as plants became larger the 1st pot was larger than the 6th pot (Figure 6). At the end of the experiment samples of water from the mat were analyzed for N, P, K, Ca, Mg, Zn, Cu, Fe and Mn. Only the data for N and Fe are shown (Figure 7a and 7b). The amount of N, K, P, Ca, Mg and Mn in the mat decreased from position 1 to 5; whereas the amount of Fe increased the greater the distance from the trough. Zn and Cu remained nearly constant. In general, the amount of each nutrient at position 6 was greater than at position 5. The evaporation of water from the mat edge at position 6 probably concentrated the nutrients. The data suggests the first pot removes more nutrients, such as N, relative to the water uptake, and the next pots in the row receive decreased concentration of some nutrients the greater the distance from the trough. Future work will identify the nutrient concentration needed at different stages in development.

Conclusion

A CWT irrigation system is adaptable for the production of many container-grown plants and provides several advantages over other irrigation systems.

1) Unlike any other irrigation system, CWT maintains the same water/air ratio in all containers on a bench regardless of any differences in evapotranspiration. Thus the effect of the micro-environment on water use, in different areas of the greenhouse, is not a factor in water management. With other irrigation systems the water/air content changes between irrigation cycles and the containers in different areas of a bench will lose water at different rates.

2) CWT-irrigated plants are rarely under water stress conditions; the stomates remain open for CO_2 entry, so photosynthesis is not inhibited. Crop uniformity should improve and labor and space will be used efficiently.

3) The water or nutrient solution does not run off the bench or drip from pots onto the floor as with overhead irrigation or some types of subirrigation systems. The nutrient solution is held within the capillary mat under a constant negative water potential.

Other advantages include:

4) no pump or large tank is required for recirculation as with ebb and flood irrigation;

5) existing greenhouse benches are easily retrofitted;

6) components are readily available and relatively inexpensive; and

7) disease potential is reduced as the solution is not recirculated and therefore little chance exists to spread disease.

Literature Cited

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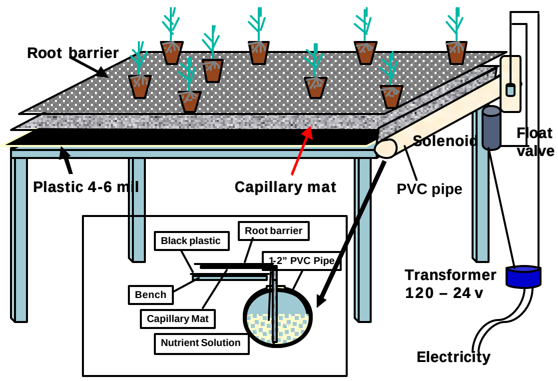


Figure 1. Construction of CWT.

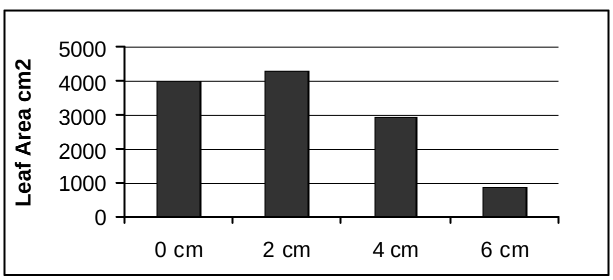


Figure 2. The leaf area of geraniums grown at CWT of 0, 2, 4 and 6 cm.

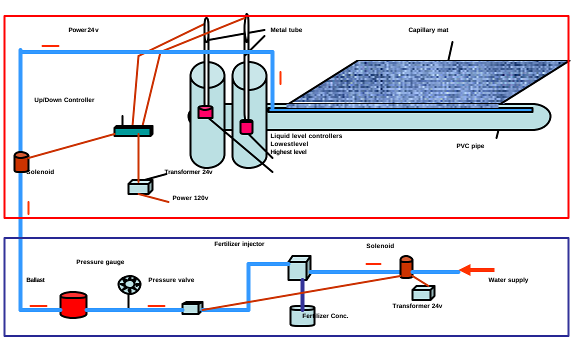


Figure 3. Control system for the fluctuating CWT.

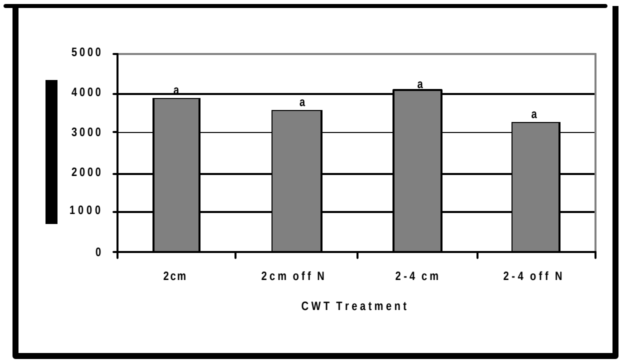


Figure 4. Leaf area of geraniums grown with CWT at 2 cm and a fluctuating CWT 2-4 cm and with on day and night or on only during the day.

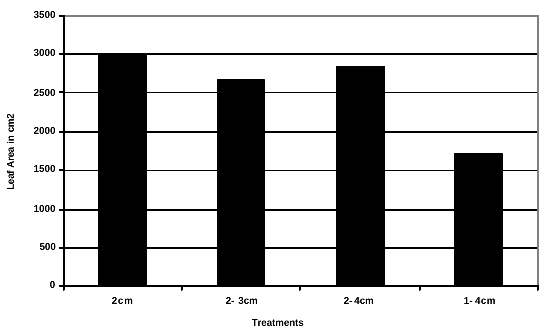


Figure 5. The effect of fluctuating CWT at 2 cm, 2-3 cm, 2-4 cm and 1-4 cm on geranium leaf area.

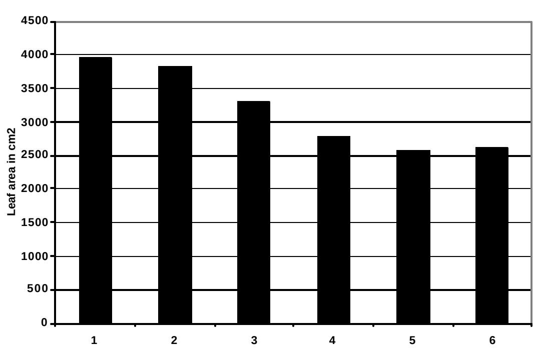
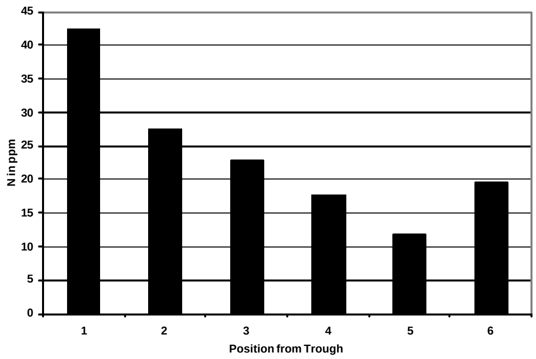


Figure 6. The effect of position of container from the trough on the leaf area of geranium.

a.



b.

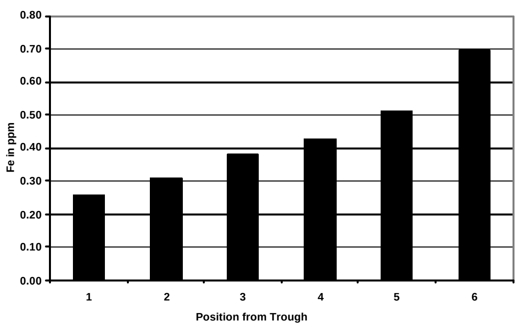


Figure 7. The effect of container position from the trough on the concentration of (a) nitrogen and (b) iron in the capillary mat at the end of the experiment.