Automatic Controlled Water Table Irrigation for Container Production©

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The controlled-water-table irrigation system (CWT) was used to automatically irrigate many crops. Crops included germination and growing seedlings in plug trays, production of 15 cm pots of geranium, poinsettias, and chrysanthemums, and production of woody plants in 2.5 cm x 2.5 cm x 15 cm propagation trays and in 1-gal containers. The CWT provides nearly constant water/air ratio in the growing medium if the system is established properly. The water/air ratio in the growing medium can be changed depending on species, stage of growth, or the degree of water stress desired by raising or lowering the water source relative to the bench. The optimum distance between the water table surface and the bottom of the pot was 3 to 4 cm for 2-cm plug trays and approximately 2 to 3 cm for 10- to 20-cm containers.

INTRODUCTION

A controlled-water-table-irrigation system (CWT) was developed and used for the automatic irrigation of many greenhouse and nursery crops (Buxton and Jia, 1995, 1996; Buxton et al. 1994; and Hoffman et. al., 1996). Several irrigation systems utilize the same principles employed in the CWT system. Post and Seeley (1943, 1947a, 1947b) and Seeley (1947, 1948, 1950) developed an irrigation system consisting of maintaining a constant water table in sand. Saarinen (1994) and Saarinen and Reinikainen (1995) proposed a system similar to CWT for tomato production on peat boards. Snow and Tingey (1985) developed a system that could impose stress on roots in individual pots. For space exploration, Dreschel et.al. (1987, 1989) reported on a porous polyethylene tube and Koontz, et. al. (1990) reported on a stainless steel membrane surface; Tibbitts and Cao (1994, 1995) and

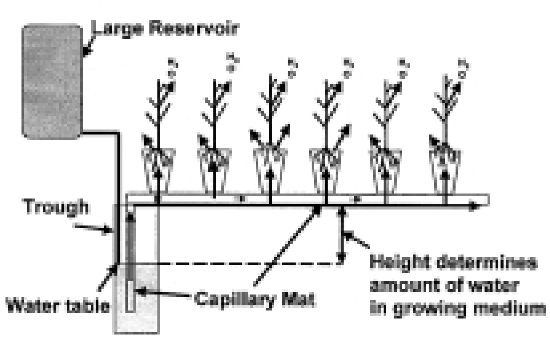

Figure 1. Controlled water table irrigation system.

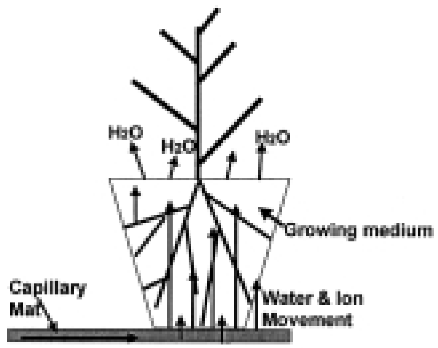

Figure 2. Movement of water from the capillary mat into and upward in growing medium and loss through evapotranspiration.

Cao and Tibbitts (1996) suggested a similar method for maintaining a constant, negative pressure.

PRINCIPLES

A capillary mat moves water from a water surface (water table) upward to and across the bench surface (Fig. 1). Growing medium in pots placed on the capillary mat surface absorbs water by capillarity until an equilibrium is established within the water distribution system (Fig. 2). The vertical distance, between the water table and the bottom of the container, determines the amount of water and therefore the amount of air in the growing medium. Changing the vertical distance between the water table and the bottom of the container changes the ratio of water to air in the medium. Once established the relationship between water and air remains nearly constant.

DESCRIPTION OF CONTROLLED-WATER-TABLE IRRIGATION SYSTEM

Level Bench. Bench must be flat and level. If not level some areas on the bench surface will be higher or lower relative to the water surface in the trough (see below) and the water/air content will be different in these areas.

Plastic Sheet. Plastic (4 to 6 mil) is placed on the bench surface to separate it from the capillary mat.

Capillary Mat. The capillary mat covers the bench surface and one side of the mat is suspended in a trough. The capillary mat (Vattex) moves the water from the trough upward to the bench surface and then horizontally across the bench.

Trough. The trough is installed along the side of the bench and was constructed from PVC pipe (3.75 to 5 cm) or rectangular shaped aluminum. A ½-inch slot was cut in PVC pipe the length of the trough for the capillary mat. The trough size could be smaller; the limiting factor is how fast and how uniformly the water can be replaced in the trough.

Water or Nutrient Solution Source. If only water is used the solenoid could be attached directly to the water source in the greenhouse. If fertigation is used a large barrel with a nutrient solution could be placed above the bench and the nutrient solution gravity fed to the solenoid. A second and more commercially feasible system is to attach the water line, running to the solenoid, to a water line running from an injector. For most fertilizer injectors a ballast tank will need to be installed for the injector to provide the correct ratio of nutrient concentrate in the water supply.

Water Level Control. The water level in the trough is controlled with several types of mechanical and electric controls. The control could be a float valve or a liquid level controller to detect the water level in the trough and that then opens and closes a solenoid valve to control the flow of the nutrient solution into the trough.

Solenoid Valve. A standard greenhouse 24-volt AC solenoid valve is opened and closed by the liquid level controller.

Containers. Any size of container up to 20 cm tall will work with the system. The bottom of the pot must have holes that touch the weed barrier/capillary mat so that the growing media is in contact with the capillary mat.

RESULTS

Many crops have been irrigated throughout their crop cycle with the CWT.

Cuttings of woody plants were rooted in 10-cm pots and in a 3 cm × 3 cm × 20 cm cells and then placed on CWT and grown for several months. Also rooted cuttings of some woody plant species were grown in 1-gal containers. The water table was maintained at 2 cm below the bench surface for both types of containers.

Flowering bedding plant and vegetable seeds were germinated with no covering in plug trays and then grown to maturity. The water table was maintained at 3 to 4 cm below the bench surface. From 0 to 3 cm the surface of the growing medium did not provide sufficient O_2 for good germination. Above 4 cm the water content in the growing was too low and seedlings were severely stressed.

Geraniums, poinsettia, and chrysanthemum from rooted cuttings were automatically irrigated with CWT in 15-cm pots until maturity. The optimum CWT distance below the bench was 2 to 3 cm. If the water table was level with the bench surface (0 cm), roots would not grow into the water-saturated medium at the bottom of the pot. At 4 to 6 cm below the bench surface, plants were stressed and were not nearly as large as those grown at 2 cm.

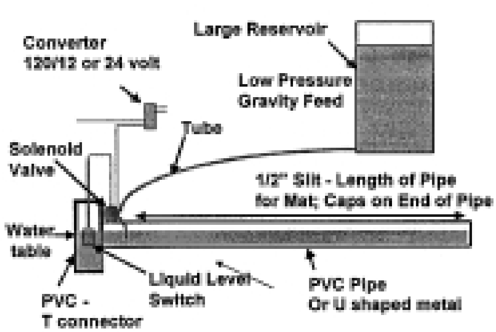

Figure 3. An electric control system to control the level of water in the trough.

Figure 4. Rooted woody plant cuttings in 10-cm containers irrigated with CWT.

Figure 5. Geraniums in 15-cm pots produced using CWT irrigation.

DISCUSSION

The CWT irrigation system has been used to produce many container-grown greenhouse and nursery crops. The significant advantages of CWT are:

Automatic. The plants determine the use of water. As plants absorb water from the growing medium it is replaced to establish the same water/air equilibrium.

Optimum Air/Water in Medium. The water/air ratio can be adjusted to desired level for different cultural practices and type and depth of growing medium.

Uniform Water. With a level bench the water/air ratio remains the same regardless of container location on bench. In areas of high evapotranspiration more water is used but the water/air ratio remains the same as in other containers in less dry areas on the bench.

No Runoff. The water or nutrient solution is contained within the mat under constant negative pressure and there are no water disposal issues.

Low Disease Potential. The water moves only upward in the growing medium; therefore water in contact with a medium, containing possible disease organisms, does not move out into the mat and to other containers.

Inexpensive. Compared to ebb and flow systems, no pumps or large holding tanks are required and the bench surface is not as expensive.

Retrofit to Existing Benches. Most benches that can be leveled can be retrofitted with CWT.

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