

## Water-Conserving and Runoff-Reducing Production Systems for Containerized Plants: Some Examples of Recently Developed Technologies<sup>1</sup>

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Ornamental plant production is the fastest growing agricultural sector in the US, and Florida is the second largest producer of nursery plants in the country with an industry value of \$15 billion in 2006 (personal communication, FNGLA) and about 4,500 registered wholesale nursery growers (NASS, Census of Agriculture, 2004). Approximately 74% of the value of Florida landscape and foliage crops is from container-produced material (Hodges and Haydu, 2002; Haydu et al., 2005; Hodges and Haydu, 2006). The area of container-grown nursery plants in Florida was approximately 15,000 ha (37,000 acres) in 1995 (USGS, 1999). Because the ornamentals produced in Florida are also shipped out of state, the production likely will continue to increase as the population in Florida and in other states increases. The US Census Bureau (2005) projects that the population of Florida could increase to 28.7 million people in 2030, which would be an 80% increase from 2000. This will also result in rapid growth of residential construction and a growing need for landscape plants, stimulating growth of the ornamental industry in Florida.

Container production of marketable landscape ornamentals using overhead irrigation requires large amounts of water to overcome relatively small root volumes and deflection of water by plant canopies (Beeson and Yeager, 2003). In Florida, most of the container-grown ornamental plants are irrigated with overhead sprinkler systems. Of the 50 to 100 inches of water applied per acre per year for irrigation, as little as 25% of the water applied overhead can enter the containers, and crops utilize only up to 50% of applied fertilizer (Haman et al., 1998). When spacing is factored in, a high proportion of water applied through overhead irrigation falls between containers and thus is unavailable to the container substrate (Furuta, 1974; Beeson and Knox, 1991; Beeson and Yeager, 2003). Over the course of a production period, only 13% to 20% of the water applied overhead is retained for plant growth, the rest becomes runoff or evaporation (Weatherspoon and Harrell, 1980).

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As population and industrial development increase, limited water supply will likely become a major constraint upon the growth of the ornamental industry. Consequently, water-conserving technologies for nurseries will be essential and perhaps mandatory. Further, because in some instances poor irrigation practices have resulted in environmental degradation due to the transport of nutrients, pesticides, salt, and trace elements to surface- and ground-water, irrigated agriculture is facing increasing public pressure and the threat of increased regulation. In light of this, there is an increasing interest in new, water conserving production systems developed for containerized plant production in outdoor nurseries for water conservation in place or under development, we describe those with which we have first-hand experience.

### **Microirrigation Based Technologies**

One early advance in water conservation technologies was the development of microirrigation (Figure 1a). This method, when designed and managed appropriately, significantly reduces water usage (Haman, 2000; Haman et al., 1998a). There are many different types of microirrigation systems which incorporate frequent applications of water in small flow rates directly on or below the substrate surface. At container nurseries, where potting substrates are highly porous, the most common microirrigation systems consist of small spray stakes to distribute the water over a significant portion of the surface area to assure even moisture distribution (Figure 1b). Ideally, only enough volume of water is applied to the root zone in quantities that are approximately equal to the consumptive use of the plants. In addition, nutrients and other production related chemicals applied with water can be controlled with increased accuracy. However, microirrigation has been labor- and cost-prohibitive for production in smaller (#1) containers because of higher cost of installation and maintenance when compared to the overhead irrigation system. Consequently, it has been mainly used to produce larger plants (#5 and larger). Overall, water requirements are much smaller in well-managed microirrigation systems, and the low pressure delivery requires less energy for pumping water than

high pressure systems. Some disadvantages, however, can include lack of frost protection, clogging of emitters by substrate particles, organic matter, algae, or chemicals, and dislodging of emitters from containers.

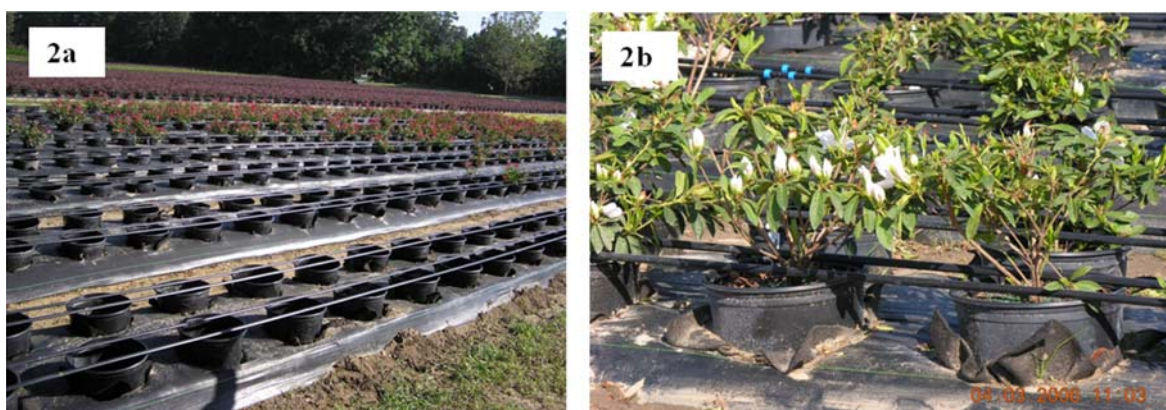
Over time, researchers, producers and entrepreneurs have developed various methods to utilize the concept of microirrigation to improve irrigation and overall production efficiency, especially for smaller containers. In a few Florida nurseries, plants are set at specific intervals on ground cloth and commercial vegetable production drip tape is strung across the top of the containers as the water source. In the absence of overhead irrigation, occurrence of disease and use of pesticides is reduced. Benefits of this drip tape system can include reduced water use, nutrient runoff, fertilizer use, and incidence of foliar disease. An advanced example using drip tape is Gro-Eco®, a patented, raised bed pot-in-socket production system. In this system raised beds are covered with weed barrier fabric and containers are placed in preformed sockets (Figure 2a). Drip tape is used to distribute water and nutrients directly to containers (Figure 2b). The raised beds improve drainage and keep containers aligned under the nozzles, while the weed barrier and water distributed via drip tape within a bed help stabilize soil temperature around the containers.

### **Subirrigation Based Technologies**

This irrigation method utilizes capillary action within the substrate to draw water from a source through drain holes at the bottom of a container. Successful use of capillary systems depends on the capillary rise of the substrate. Substrates used in outdoor production generally have poor to moderate capillary rise. Thus capillary systems are generally limited to production of #3 containers or smaller, depending on the location of roots relative to the bottom of a container. However for plants nearing market size where roots have colonized the container volume, subirrigation can be used for most container sizes. By using flooded trays it is possible to recycle nutrients along with the water. This results in reduced usage of water and fertilizer, and in reduced runoff at a nursery.



**Figure 1.** Microirrigation is a water-conserving technique of supplying irrigation water and fertigation to plants in containers. (1a) A microirrigation system with drip tubes delivering water to containers. (1b) A close-up of spray stakes in pots.



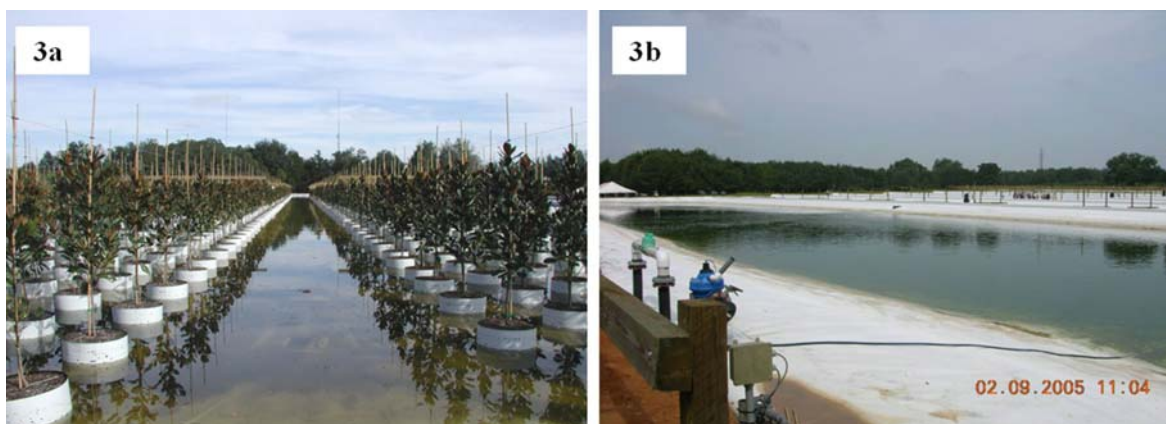
**Figure 2.** Gro-Eco® production system utilizes the concept of microirrigation to deliver water to pots placed in raised bed sockets. (2a) Newly installed beds with some planted pots in the background. (2b) A close-up of the pots showing the drip tape which delivers the water and nutrients to the plants.

Subirrigation systems are infrequently used for outdoor production of containerized plants at commercial nurseries. However several nurseries in Florida are successfully using subirrigation principles. The most versatile example in terms of container size is the Holloway Irrigation System in use at Holloway Tree Farm. This is an ebb and flow system in which plants are placed on an impermeable surface in graded basins (Figure 3a) that are periodically flooded for irrigation. Water depth is adjusted to overcome low capillary rise, expanding its application beyond #3 containers. Excess water is then returned to the retention reservoir (Figure 3b). Runoff resulting from rainfall is also collected in the reservoir for future irrigation use. Consequently, dissolved nutrients are retained in the pond,

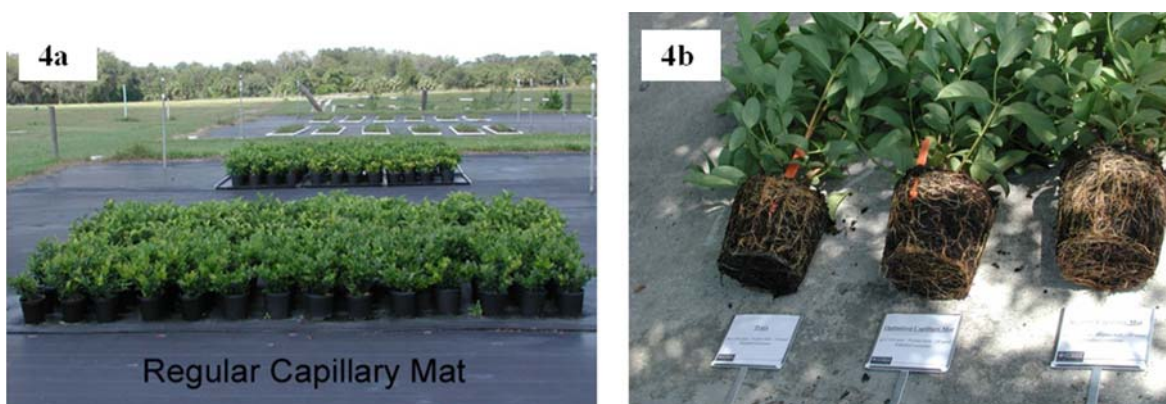
eliminating groundwater and minimizing surface water pollution due to deep percolation and runoff, respectively. Nutrients are only released to the environment during periods of exceptionally heavy rainfall. As in greenhouse ebb and flow systems, unutilized nutrients in the retention water are reapplied at each irrigation event. The amount of water released from a reservoir strongly depends on its size and water level management (Haman et al., 2005).

Another method utilizing capillary action to deliver water to containerized plants is the capillary mat system. This is a plant demand-driven system in which water holding mats are placed on the nursery bed and plant containers then are placed on top of the mats (Figure 4a). Beeson and Haydu (2002)





**Figure 3.** Containerized plants growing in an ebb and flow basin lined with an impermeable surface (3a) to which water is supplied from a detention pond which collects rainfall and the recycled water (3b) in the Holloway Irrigation System. Figure 3. Containerized plants growing in an ebb and flow basin lined with an impermeable surface (3a) to which water is supplied from a detention pond which collects rainfall and the recycled water (3b) in the Holloway Irrigation System.

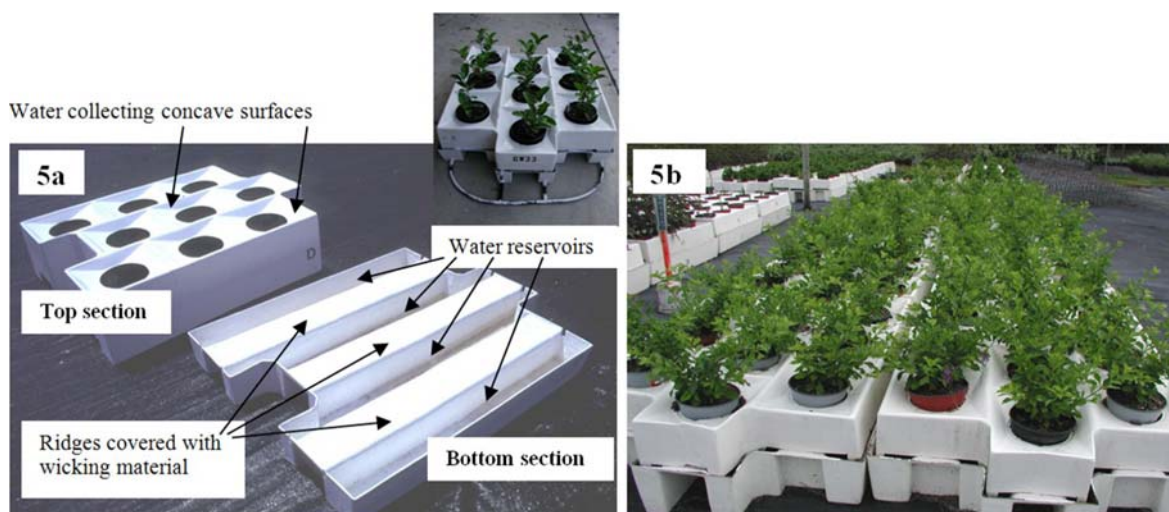


**Figure 4.** Capillary mat system. (4a) A photograph showing the experimental capillary mat set-up. (4b) From left to right: roots of plants grown outdoors in large, flat trays (left); on the two prototype capillary mats.

examined the efficiency and economic feasibility of two prototype capillary mat systems (Solen Textiles Inc, Quebec, Canada) at the UF Mid-Florida Research and Education Center in 2001. Results indicated that the best prototype was economically feasible and that initial investment cost could be recouped in a relatively short period. This prototype required 60% less water than the typical overhead system and resulted in a shorter production period. Since the study, this prototype has undergone several improvements, including installation of drip tubes to supply water. However, water can still be supplied through overhead irrigation, by using the installed drip tubes, or both. This system is sold as Aquamat and is employed at least one nursery in Florida. Because the maximum depth of water retained in the mat is low, this system is limited to production of #3 containers or smaller.

A modification of subirrigation that combines overhead and subirrigation concepts is the Multipot Box System. It was designed by the University of Florida for use under overhead irrigation systems to capture the water falling between containers, making it available when needed by the plants (Figure 5). It consists of two sections: upper and lower. The lower section forms a water reservoir with three ridges covered with wicking material. The upper surface increases the effective surface area and captures most overhead irrigation water or rainfall. Boxes were designed to be placed end-to-end, creating a continuous surface area to collect water. Introducing multipot boxes under a sprinkler system significantly increases the efficiency of water use. During the rainy season, boxes function as rain harvesting/storage devices and they often require very

infrequent irrigation. Without the box, water storage capacity of a container is very low and allows for no more than 2 to 3 days between water applications. The amount of water saved in a specific nursery depends on box arrangement and width of the alleys. However it can increase water application efficiency from a typical 15-20% of a system without boxes to above 70% with boxes (Haman et al., 1998b). In wet climates the contribution of rainfall is the most significant. During the two seasons in which the system was tested, 30 to 50% of the total rainfall was harvested for plant use. The amount that can be harvested depends on the frequency and timing of the rain, and on the amount of rain in consecutive rainfall events. At the time of this publication, this system was not available commercially.



**Figure 5.** Components of a multipot box system (5a) and plants growing in the multipot boxes (5b).

## Summary

Summary: The growth of the nursery industry in Florida and the presence of water quantity and quality challenges for the growers are necessitating the incorporation of water conserving methods in the production of containerized plants outdoors. We have outlined a few, recently developed systems which utilize the concepts of microirrigation and subirrigation to conserve water quantity and quality while achieving acceptable plant growth. We recommend investigating other published information to evaluate and decide which system would work best for a particular nursery situation.

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