Container Nursery Irrigation Basics©

Robert L. Geneve, Susmitha Nambuthiri and Sharon Kester
Department of Horticulture, University of Kentucky, Lexington, Kentucky 40546, USA
Email: Rgeneve@uky.edu

INTRODUCTION

Container nursery production is reliant on frequent irrigation to maintain appropriate substrate moisture and sustain quality plant growth. Irrigation water management is a key production consideration and critical for reducing the impact of fertilizer and pesticide runoff from nursery production (Beeson et al., 2004). The objective of this paper is to provide some basic information regarding choices for container irrigation leading to more sustainable choices in the nursery. The paper will be organized into sections on: (a) Types of irrigation systems, (b) Irrigation efficiency, and (c) Irrigation scheduling.

TYPES OF IRRIGATION SYSTEMS

There are two basic systems used for container irrigation. These include overhead sprinkler irrigation and micro-irrigation. Selection of which system to employ depends on site topography, water source and quality, and cost.

Overhead sprinkler irrigation is the traditional, popular nursery irrigation system. It is relatively inexpensive to set up, but it can be an inefficient system in regards to water use and high operational cost of pumps. The three basic types of overhead irrigation systems include rotary, stationary, and traveling boom systems (Figs. 1 and 2).

Rotary sprinklers utilize a rotating head with nozzles that distribute a large droplet size stream of water over a large area of the crop. The two basic nozzle designs for rotating sprinklers are impact rotors and spinning heads. These can be located on stationary risers within the crop or mounted overhead on overwintering structures.

Stationary sprinklers do not rotate. Water is forced through the head or against a deflection plate to form a smaller droplet size and constant uniform coverage. Stationary sprinklers are usually placed on risers within the crop and like rotating nozzles can be configured in different patterns from 45 to 180 degrees. Stationary sprinklers can be designed to operate at lower water pressure, but can be more prone to clogging compared to rotary sprinklers.

Traveling booms are most common for use within protected cultivation such as greenhouse production, but they can be designed to function in outdoor nursery settings as long as the crop structure is not too tall. They tend to deliver water more efficiently and uniformly compared to other overhead irrigation systems.

Micro-irrigation is a low volume system that delivers water directly to the container. It is generally more water efficient compared to overhead irrigation. The three basic types of micro-irrigation utilize micro-sprayers, drip emitters, or in-line drip tubes (Fig. 3). Micro-sprayers or spray stakes deliver water in a sprinkler pattern over a specific diameter on the surface of the container. Drip emitters are placed at the end of a "spaghetti" tube and drip water into the container over a limited area. Each drip tube emanates from a main water line and like micro-sprayers more than one can be placed in each container. In-line systems do not have extension tubes or need specific drip emitters and are best used in crops on a regular spacing in rows. A punch is used to create an opening in the main poly line over each container to drip water.

Micro-irrigation systems are generally more susceptible to clogging compared to overhead irrigation systems and therefore a water filtering system is usually included to exclude particles or debris from the line. Also, because these are low pressure, low volume systems, grade changes across the nursery row can impact water delivery uniformity. Including in-line pressure equalizers will help provide uniform distribution of water over the entire emitter line.

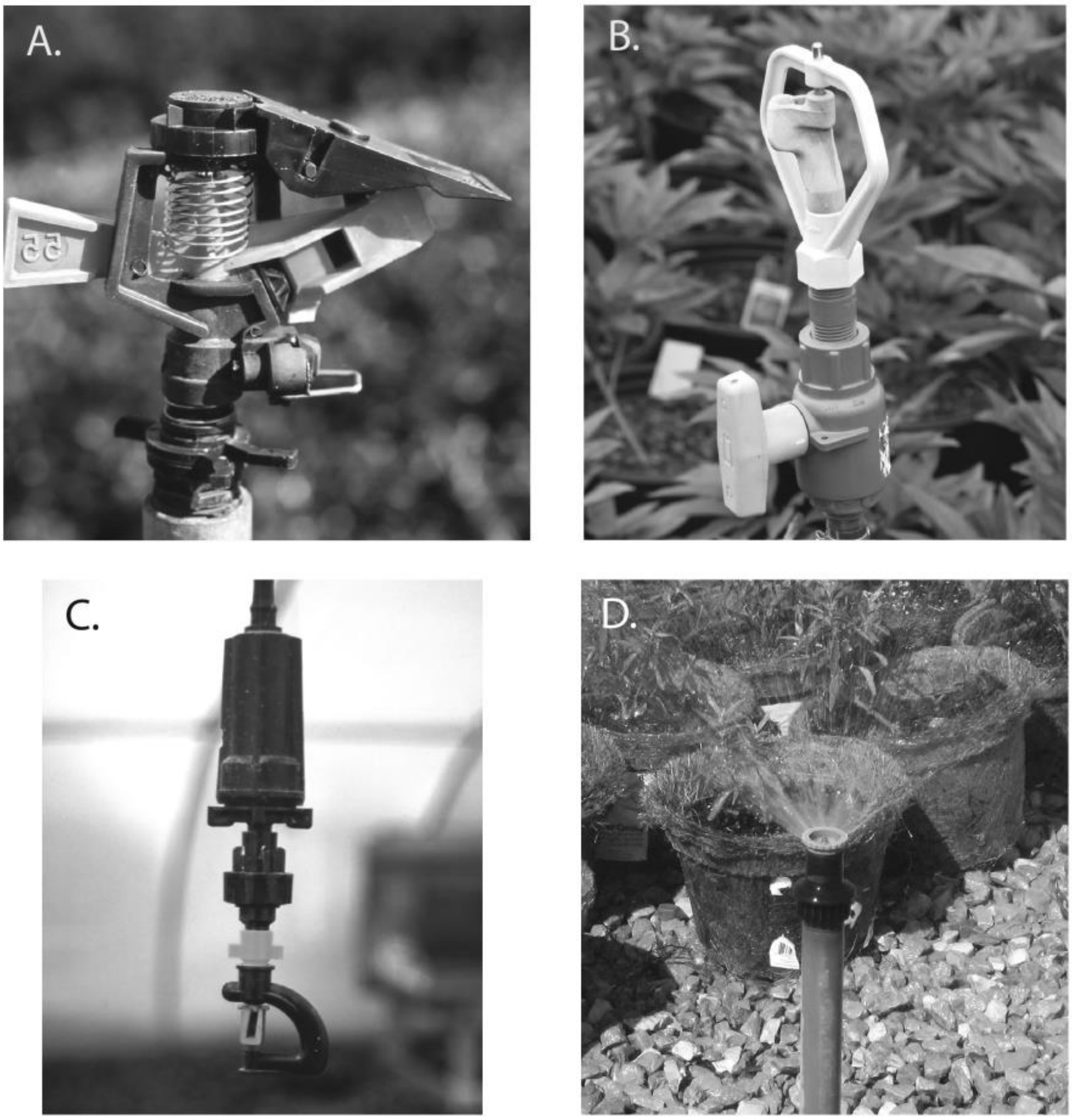

Fig. 1. (A) Sprinkler head types; (B) Rotary impact head sprinkler; (C). Rotary spinning head sprinklers; and (D) Stationary head nozzle.

Fig. 2. An outdoor nursery traveling boom system.

Fig. 3. Three basic types of micro-irrigation systems: (A) Micro-sprayers, (B) Drip emitters, and (C) In-line drip tubes.

IRRIGATION EFFICIENCY

Irrigation efficiency is a function of irrigation system performance and uniformity of irrigation water application. For most container nursery production, irrigation is usually delivered by overhead sprinklers. Overhead irrigation is relatively inefficient for a number of reasons including:

- High operating pump pressure.
- The large water droplet size is needed to reduce evaporation during application which can lead to water and nutrient leaching.
- Poor target water application.
- Non-uniform irrigation distribution and evaporation during application.

The amount of water reaching the container surface during overhead irrigation can be between 25 to 70% depending on container spacing (Zinati, 2005).

Overhead irrigation efficiency can be improved by: (a) grouping plants into irrigation zones based on relative water usage, (b) crop spacing, and (c) cyclic irrigation. By grouping plants into water use irrigation zones, a grower can irrigate the crop with less water waste than would occur if plants with dissimilar water use requirements were irrigated side-by-side. One of the biggest impacts on irrigation efficiency is crop spacing because the larger the spacing the greater the non-targeted water application becomes. For example, a 1-gal container spaced on 20 in. vs. 10 in. centers reduces irrigation capture by the container surface by about 60% (Table 1).

Table 1. Overhead irrigation application efficiency based on spacing of 1-gallon nursery containers.

	Spacing on a square		Spacing on a triangle	
On-center spacing (in)	Area covered (in)	Interception efficiency (%)	Area covered (in)	Interception efficiency (%)
10	100	79	87	91
15	225	35	195	41
20	400	20	346	23

Adapted from Owen and Stoven (<http://www.climatefriendlynurseries.org/resources/irrigation_efficiency.pdf>)

A second way that overhead irrigation efficiency can be improved is by adopting a cyclic irrigation strategy. Most soilless container substrates have a low capacity for retaining water and nutrients, and supplying a large amount of irrigation at one time can result in substantial leaching. Typically cyclic irrigation systems apply water for brief intervals separated by a waiting period rather than applying water all at once. Cyclic irrigation was found to improve irrigation application efficiency by allowing time for water to gradually move through the micro-pores of the container substrate therefore reducing leaching. Along with a substantial improvement in water use, as much as a 30% reduction in nitrogen leaching was observed with cyclic irrigation compared to a single application watering regime (Lamack and Niemiera, 1993; Karam and Niemiera, 1994).

Compared to overhead irrigation, micro-irrigation is relatively efficient because it uses lower operating pump pressure, has high irrigation application uniformity, and targets water directly to the container. Greater efficiencies can be realized by applying cyclic irrigation strategies or by adopting a pot-in-pot production system. Under a pot-in-pot production system, roots experience a moderated temperature similar to the soil temperature below ground, which reduces evapotranspiration and production water use compared to above-ground containers.

IRRIGATION SCHEDULING

Irrigation can be scheduled based on either: (a) static controllers, (b) plant-based control, or (c) substrate moisture sensors. Static controllers are the simplest and most common irrigation scheduling system. It is accomplished with timers that open a solenoid for a set time to provide a pre-set water amount. Static control is the least efficient irrigation scheduling method because it does not automatically respond to changes in the environment that impact optimal irrigation scheduling. Its efficiency can be improved by installing rain sensors to postpone irrigation events following rain. The grower may also manually alter the quantity and frequency of irrigation based on weather information.

Plant-based control relies on information provided to a crop model that schedules irrigation by monitoring environmental and/or crop physiology. Plant evapotranspiration models have been developed and are beginning to be commercialized for nursery production. These systems usually utilize weather station data and a computer determines irrigation scheduling using a mathematical model specifically designed to estimate daily water loss (evapotranspiration) for each crop or crop group. Irrigation models are also available that rely on measuring crop transpiration. Various sap flow meters are available that fit around the main tree stem and indirectly measure transpiration. Irrigation decisions are similar whether the model is based on estimating evapotranspiration (water loss from crop and substrate) or crop transpiration. Irrigation is then applied to replace water used by the crop on the previous day or days.

Substrate moisture sensors directly monitor water loss from the substrate. There are basically two types of sensors — tensiometers and electrical resistance sensors (Fig. 4). Tensiometers measure substrate suction and control irrigation based on substrate matric potential settings. Electrical resistance sensors measure electrical resistance and relate the resistance reading to substrate moisture levels.

Fig. 4. Substrate moisture sensors (A) tensiometer, and (B) electrical resistance sensor.

Irrigation events are triggered when the sensor indicates the substrate moisture content has reached a predetermined set-point. A drawback with most sensor-based irrigation scheduling is the extensive wiring that is required to link the sensor to the controller and the controller to the solenoid. However, remote sensing has recently become available and will eventually replace hard-wired systems for acquisition and control of irrigation.

Soil moisture sensors and other environmental sensors are now becoming affordable. Therefore, utilization of these technologies is no longer restricted to research applications. Recently, commercial agricultural producers have begun adopting sensors to guide irrigation management decisions (Beeson et al., 2004; Rundel et al., 2009). These sensors have the potential to allow growers to utilize more precise irrigation practices that improve efficiency and reduce water use.

Literature Cited

Beeson Jr., R.C., Arnold, M.A., Bilderback, T.E., Bolusky, B., Chandler, S., Gramling, H.M., Lea-Cox, J.D., Harris, J.R., Klinger, P.J., Mathers, H.M., Ruter, J.M. and Yeager, T.H. 2004. Strategic vision of container nursery irrigation in ten years. J. Environ. Hort. 22:113-115.

Fain, G.B., Tilt, K.M., Gilliam, C.H., Ponder, H.G. and Sibley, J.F. 1998. Effects of cyclic micro-irrigation and substrate in pot-in-pot production. J. Environ. Hort.

14:215-218.
Karam, N.S. and Niemiera, A.X. 1994. Cyclic sprinkler irrigation and pre-irrigation substrate water content affect water and N leaching from containers. J. Environ. Hort. 12:198-202.
Lamack, W.E. and Niemiera, A.X. 1993. Application method affects application efficiency of spray stake irrigated containers. HortScience 28:625-627.
Rundel, P.W., Graham, E.A., Allen, M.F., Fisher, J.C. and Harmon, T.C. 2009. Environmental sensor networks in ecological research. New Phytol. 182:589-607.
Yeager, T.H., Gilliam, C.H., Bilderback, T.E., Fare, D.C., Niemiera, A.X. and Tilt, K.M. 1997. Best management practices guide for producing container-grown plants. Southern Nursery Association, Marietta, Georgia, USA.
Zinati, G. 2005. Irrigation management options for containerized-grown nursery crops. Rutgers Coop. Res. and Ext., Rutgers University, New Brunswick, New Jersey, USA. URL: <http://irrigationtoolbox.com/ReferenceDocuments/Extension/Eastern%20States/Irrigation%20Management%20Options%20for%20Containerized-Grown%20Nursery%20Crops.pdf>