

# Sustainable Nursery Irrigation Management Series

## Part II. Strategies to Increase Nursery Crop Irrigation Efficiency

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Part II discusses strategies to increase irrigation efficiency. Because irrigation is so critical to container production and most of the water associated with nursery production is applied to container plants, strategies are discussed largely in the context of container production.

Nursery irrigation management is a major concern for many nursery producers, especially container producers. Extension publication, "W 278: Part I. Water Use in Nursery Production," discussed competition for water and gave a general overview of water use in nurseries. Part II discusses strategies to increase irrigation efficiency. Because irrigation is so critical to container production and most of the water associated with nursery production is applied to container plants, strategies are discussed largely in the context of container production.

Growers must make many irrigation management decisions on a daily basis, including when to irrigate, how much water to apply, which plants to irrigate and how to maximize efficiency. They also must plan for and manage water supplies in order to meet local and state water regulations (Figure 1). Increasingly, competition for water resources is affecting how these decisions are made.

Creating more efficient water-use systems can ease competition for water. Many factors contribute to overall irrigation system efficiency. Irrigation application efficiency is the proportion of total water applied that is intercepted and retained by the container (or root zone in the field). Water loss to excessive leaching, evaporation, wind, container spacing, canopy

*Figure 1. Often newly planted liners are the first plants to be irrigated.* *Photo credit: Amy Fulcher*

shedding and poor irrigation system design can decrease irrigation application efficiency dramatically, whereas recovery and reuse of surface water runoff and subsurface flow can increase irrigation application efficiency. Enhancing irrigation efficiency often increases crop water use efficiency.

## Scheduling Irrigation

Scheduling irrigation applications has been the focus of much agricultural research. Scheduling can be relatively static and arbitrary, substrate/soil moisture-based, or plant-based.

### Static

The conventional container production practice is to irrigate once per day by automatic timers or manually. Historically, these irrigation events were scheduled to begin predawn to minimize losses due to wind and evaporation and so that most irrigation would occur before employees arrived. However, applications are made commonly during daylight hours due to the number of hours needed to deliver water to the entire nursery every 24 hours. The time that irrigation begins may be the same time every day using timer-based irrigation or may be completely arbitrary (i.e., when an employee remembers and has time to turn on the irrigation). With static irrigation, application is not linked directly to plant or substrate moisture status. Irrigation is not adjusted often for changes in evaporative demand due to weather changes, but rather is limited to gross changes when the seasons change. A simple way to save water when using timer-based irrigation scheduling is to install a rain gauge that will prevent irrigation from being applied if a set amount of rainfall occurs.

### Substrate Moisture-based

Substrate moisture measurements consist of either substrate water potential or substrate moisture content and generally rely on moisture probes (Figure 2) or gravimetric (weight) measurements. Tensiometers reflect actual water potential but are difficult to use in coarse nursery substrates and may require regular maintenance. Some companies are now developing tensiometers that are better suited for container substrates. Capacitance probes and gravimetric techniques measure substrate water content. They do not reflect water potential and, thus, the actual availability of water. Advantages of using substrate moisture-based irrigation include the fact that it can reflect root-to-shoot signaling in response to substrate moisture conditions and can be relatively easy to automate.

Determining how to position a substrate moisture probe is challenging. Scientists are still investigating the ideal probe number per container, number of containers with probes per crop, probe orientation and probe placement within containers. However, studies at nurseries have shown that a very small number of probes involving modest financial investment can be effective in reducing water use without sacrificing plant quality or time to produce a crop. A universal substrate moisture level on which to base irrigation (irrigation set point) would facilitate adoption of this technology but may not be likely due to the variability in types of substrates used by the industry. Therefore, growers will need to do some in-house experimentation to develop irrigation set points. The set point may be affected by crop species, container size, temperature, root system size/time in current container, substrate and where the probe is placed in the container.

### Plant-based

Plant-based irrigation systems, such as leaf temperature-based, allow for environmental influence but do not account for root-to-shoot signaling and are challenging to automate. Plant-based systems can respond to the physiological changes that occur directly due to changes in plant water status, which make them very appealing to researchers and practitioners alike. However, this response can be a disadvantage for conservative irrigation schedules in certain environments, because low plant water status induced by extreme mid-day conditions could trigger irrigation when substrate moisture is not limiting. Leaf temperature, plant water potential and stem diameter fluctuations are some of the plant-based techniques that have been used to gauge water loss in horticultural crops (Figure 3). Plant-based systems are not automated easily or widely commercially available at this time.

*Figure 2. Capacitance probes are currently used by researchers and a limited number of growers to schedule irrigation.* Photo credit: Amy Fulcher

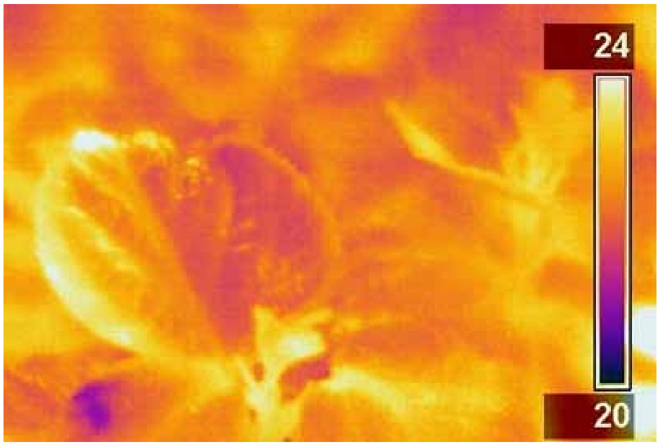


*Figure 3. Infrared temperature sensors are one plant-based technique for scheduling irrigation.* *Photo credit: Amy Fulcher*

## Irrigation Volume

The approaches mentioned above address only when to irrigate. Other approaches are needed to determine how much water to apply. Growers commonly aim to apply 0.75 to 1 inch of irrigation water daily in the summer by irrigating for a set time period. However, determining irrigation volume by a time period can lead to errors in application. Research shows that due to variation in output (e.g., water pressure) and distribution, application volume based on a time period can result in excess or inadequate irrigation. For example, nurseries expecting to apply 1 inch of water in an hour may actually apply just 0.3 inch in 60 minutes, while other nurseries apply as much as 1.3 inches. Over the course of a season, the amount of water applied within one irrigation zone in a 60-minute period can vary as much as half an inch. Therefore, it is important to determine irrigation system application rates by measuring them periodically.

Several methods can be employed to determine how much water to use to prevent applying an excessive or deficient volume of water. Irrigation volume can be based on the container leachate. Leaching fraction is the percentage of water applied that leaches or drains out of the container. A leaching fraction of 10 percent or less, allows for water and nutrient conservation. When irrigating at low leaching fractions (<10 percent), it is important to monitor substrates for soluble salts during production, especially during periods of low rainfall, as they can build up. Water balance calculations are used to estimate substrate moisture status and are calculated as the difference between water applied to the plant, both through irrigation and precipitation, and water lost through evapotranspiration. Evapotranspiration is affected by many factors, including solar radiation, humidity and mulch layer. Using an evapotranspiration model presents several challenges. For instance, evapotranspiration models are often complex, requiring that several variables be measured. A weather station and datalogger must be located on-site. Additionally, a crop coefficient must be derived empirically for every species, perhaps even at the cultivar level and possibly for different stages of development, container sizes, plant (crop) size and spacing. Daily water replacement is a practical way to approach water balance calculations. Daily water use measures how much water is lost during each 24-hour period and applies, or replaces, that volume of water minus rainfall. Daily water use measurements may be made by measuring weight or using probes to measure volumetric water content every 24 hours.

## Irrigation System: Delivery

Overhead irrigation is commonly used for plants in 5-gallon and smaller container sizes. The water is delivered by sprinklers mounted on risers on rectangular, square or triangular patterns throughout the container pad. While overhead sprinklers are easy and relatively affordable to set up, they are not efficient, because a lot of water lands between containers (Figure 4). As linear spacing between plants increases, irrigation efficiency decreases considerably, with as little as 35 percent efficiency even at close spacing (half a container diameter).

Microemitters are emitters that apply a small volume of water at low flow rates, generally to individual plants. Microemitters are often used for 7-gallon

*Figure 4. Overhead irrigation can vary significantly within an irrigation zone, across zones and over the course of a season.* *Photo credit: Amy Fulcher*

*Figure 5a. This single-irrigation emitter is not supplying water to the entire root system of this 15-gallon container. A different type of emitter, more than one emitter and/or different emitter placement is needed.* *Photo credit: Amy Fulcher*

and larger container sizes (Figures 5a, 5b). Microemitters include microsprinklers, drippers and bubblers. Microsprinklers, commonly called "spray stakes," are the most common type of microemitter in nursery production. Sprinkler heads are mounted on a stake in the container. The sprinkler head/ stake assembly is connected to the lateral line by a small diameter (1/4"-1/8") flexible tube called spaghetti tubing. Drip emitters and bubblers are not used often in nursery production because they do not apply the water to the surface of the substrate evenly, a problem that compounds the larger the container size. Also, the single-point delivery of a drip emitter can lead to water channeling through the bark substrate due to its coarse nature.

Microemitters are very efficient; when properly installed, they apply water to the root system with no overspray or wasted water. However, the particular spray patterns, placement in the container and juxtaposition to the trunk can affect the distribution of water. Two or more emitters can be used to apply water more evenly and/or to increase the amount of water applied in a given amount of time, especially for very large containers. Microirrigation systems have small orifices that can clog easily. Appropriate filtration as well as regular maintenance and cleaning are required.

Ebb-and-flow is a subirrigation technique that is used most commonly in floriculture production. An ebb-and-flow irrigation system floods the production floor, or bench, periodically, slightly submerging the base of containers for a short period to allow the substrate to absorb water by capillary action. A significant investment in infrastructure is required to develop an ebb-and-flow irrigation system. Typically, the irrigation water is captured and sanitized for reuse, making it a highly efficient system. A controlled water table also is a form of subirrigation and requires specialized infrastructure. A CWT delivers water to plants via a capillary mat that pulls water from a reservoir (trough) at the edge of the bench. Like ebb-and-flow, CWTs are used most often in floriculture. CWTs are very efficient but do require some maintenance.

Microemitters, ebb-and-flow systems and controlled water tables can be used to fertigate as well as irrigate.

## Water-conserving Strategies for Nurseries

Strategies to reduce water consumption in nurseries include grouping plants by relative water needs and container size and using cyclic irrigation. Grouping plants by perceived irrigation needs (high, medium, low) into irrigation zones is a common strategy employed by growers. Grouping plants by water needs along with proper spacing can reduce water consumption tremendously. Another conservative irrigation strategy is cyclic irrigation, in which the total daily volume of irrigation water is applied in multiple irrigation events with a minimum of one hour between irrigation events. Using cyclic irrigation can reduce runoff by 30 percent, compared with conventional continuous irrigation. Using

*Figure 5b. Microemitters used in drip irrigation deliver water directly to the root zone, eliminating inefficiency due to evaporation and nontarget application (e.g., driveways, between pots).* *Photo credit: Amy Fulcher*

amendments, such as calcined clay, to increase the substrate water-holding capacity also can reduce water use.

Growers have many options for increasing water-use efficiency in the nursery. These include refining irrigation scheduling, irrigation volume and irrigation delivery. The Extension publication, "W 280: Part III. Strategies to Manage Nursery Runoff," discusses the significance of runoff from nursery production facilities, as well as strategies for minimizing and mitigating runoff.

## Glossary of Terms

**Capacitance Probe** — Probe that measures volumetric content by measuring the dielectric permittivity of the surrounding soil or substrate. A capacitance probe determines the dielectric permittivity of a medium by measuring the charge time of a capacitor, which uses soil or container substrate as a dielectric.

**Continuous Irrigation** — Applying the total daily volume of water required by a crop in one irrigation event.

**Controlled Water Table** — Form of subirrigation. Delivers water to plants via a capillary mat that pulls water from a reservoir (trough) at the edge of the bench.

**Crop Coefficient (Kc)** — Calculation performed to estimate water use for a specific crop, sometimes at a particular growth or developmental stage. Ratio of evapotranspiration of a specific crop relative to potential evapotranspiration.

**Crop Water Use Efficiency** — Ratio of plant mass gained relative to the volume of water applied.

**Cyclic Irrigation** — Applying the total daily volume of irrigation water in multiple irrigation events with a minimum of one hour between events.

**Daily Water Replacement** — Method of refining irrigation volume by measuring how much water was lost in the previous 24-hour period and applying that volume of water.

**Ebb-and-Flow** — Subirrigation technique in which the production floor, or bench, is flooded periodically and then drained, slightly submerging the base of containers for a short period to allow the substrate to absorb water by capillary action.

**Evapotranspiration** — Combination of water loss due to evaporation from the soil surface and transpiration from the plant.

**Fertigate** — Applying water-soluble fertilizer in a low-volume irrigation system.

**Gravimetric Measurement** — Using the weight of a container to measure substrate moisture content.

**Irrigation Application Efficiency** — Portion of total water applied that is intercepted by the container (or root zone in the field).

**Leaching Fraction** — Portion of water applied that drains from the container following irrigation.

**Microemitters** — Irrigation emitters that apply a small volume of water at low-flow rates to individual containers.

**Subirrigation** — Irrigation delivery method of providing water to the root zone from the bottom of the container rather than the top surface.

## Glossary of Terms *(continued)*

**Substrate Moisture Content** — How hydrated a substrate is, often expressed as volumetric water content (see volumetric water content).

**Substrate Water Potential** — Measurement of how hydrated a soil or substrate is. Water potential indicates the availability of water to plants.

**Tensiometer** — Probe-like instrument used to measure the water potential of soil or substrate.

**Volumetric Water Content** — Fraction of the total volume of soil or substrate that is occupied by the water contained in the soil or substrate. Does not indicate the availability of water to plants.

**Water Balance Calculations** — Used to estimate soil or substrate moisture status and are calculated as the difference between water applied to the plant (irrigation and precipitation) and water lost through evapotranspiration (see evapotranspiration).

## Resources


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