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Improving Irrigation Efficiency

By implementing a water-management program, growers can save water and reduce runoff more effectively.

by Julie P. Newman

Water availability can be a major challenge for growers of containerized nursery stock, especially in areas prone to drought and in urban locations where there is fierce competition for water usage.

In many states, the implementation of water-conservation practices is more than just good business sense — conservation measures are required to comply with mandates that restrict the amount of water used by growers.

There also are federal and state regulations that pertain to water runoff. In states like California, Delaware and Maryland, growers who generate runoff containing agricultural pollutants exceeding benchmark concentrations are subject to penalties.

To conserve water and avoid contributing to nonpoint-source pollution, growers need to adopt water-management programs that include proper irrigation scheduling and runoff management. An important component of water-management programs is improving irrigation efficiency, which is the focus of this article.

To water plants efficiently, it's important that the irrigation system applies the correct amount of water to just the targeted plants instead of applying water in nontarget areas. This kind of precision requires good irrigation system design and regular audits to ensure that the system continues to perform efficiently. In addition to proper irrigation system performance, there are management practices that must be implemented to ensure efficient delivery and water usage.

Designing for efficiency. The most commonly used nursery irrigation systems include hand-watering, overhead sprinkler systems (rotation sprinklers, such as impact sprinklers and fixed nozzle) and microirrigation systems (drip microsprinklers). Hand-watering and sprinkler systems have a high potential to contribute to runoff, so microirrigation systems should be selected whenever possible.

Subirrigation systems, such as capillary mats or ebb and flow systems, can drastically reduce runoff, but they have been infrequently used for commercial production of outdoor containerized nursery stock due to poor capillary rise in the potting media. Therefore, they generally have been limited to plants in smaller containers or for plants nearing market size where roots have colonized the container volume.

When designing a sprinkler system, choose sprinkler heads with a high uniformity rating; use appropriate and uniform

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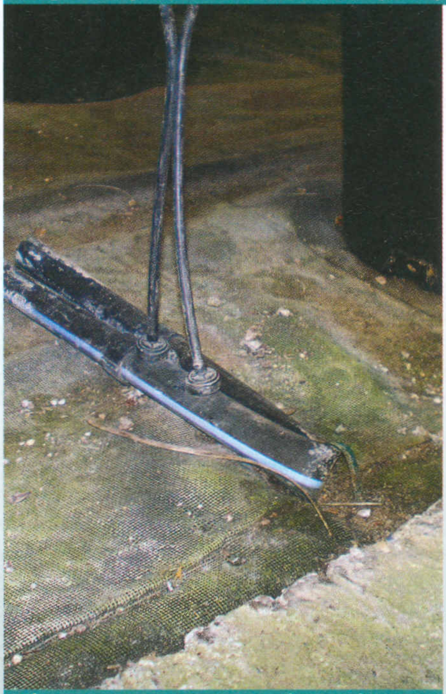
Irrigation systems should have a regularly scheduled audit to ensure that they are not leaking or clogged.



These pressure-compensating emitters deliver a more uniform amount of water to the plants when pressure fluctuates.

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nozzle sizes; and space nozzles uniformly within the irrigation zone.

When designing microirrigation systems, emitter flow rates must be correlated with plant types, media infiltration rates and container sizes in each watering zone to prevent runoff. Don't combine emitters with different flow rates in the same watering zone because this will result in some plants receiving more water than others. Also, don't place emitters where they will generate wasted water; for example, a fan spray directed partially outside of the container.

Pressure level — whether obsessively high or low — is a major factor contributing to the inefficiency of irrigation systems in both sprinkler and microirrigation systems. You can correct uneven pressure distribution by using pressure regulators or emitters that minimize pressure differences. You also can use pressure-compensating emitters as appropriate for the system type.

Evaluating irrigation system performance. When you need to save water, your overall goal should be to achieve high irrigation efficiency. An efficient system is one in which a large portion of the water you apply in your nursery is beneficially used by the plants and not wasted. But how do you measure beneficial water use and the efficiency of your irrigation system?

Well, the primary way to evaluate beneficial crop water use is by examining evapotranspiration values or weight changes in containerized plants after a 24-hour period. Unfortunately, despite their benefits in determining appropriate irrigation schedules, collecting and utilizing these types of measurements is not frequently practiced in commercial nurseries. Only a handful of specific crop coefficients (K_C values) have been determined out of the huge number of crops grown in container nurseries.

The use of K_C values is difficult because of the variable conditions commonly present in nurseries. Variables include the diversity of container sizes, plant size to container volume ratios, container spacing and varying media types. In theory, the practice of weighing plants to determine water use is a simple practice — and one that I recommend — but I haven't seen many growers out there doing it.

The easiest and most common statistics used to evaluate irrigation performance in commercial nurseries is to measure irrigation system uniformity. These are diagnostic statistics that describe how evenly water is applied to the crop rather than how efficiently you are watering. It's important to remember that although irrigation efficiency cannot be achieved without good irrigation system uniformity, even a highly uniform system can contribute to runoff if proper scheduling isn't utilized.

Distribution uniformity

Quantifying irrigation uniformity in an irrigation zone is done by comparing the average of the low quarter to the average applied amount and then converting to a percent. The distribution uniformity value is calculated as:

$$\text{Distribution uniformity (\%)} = \frac{\text{Avg. of the low 25\% of catch cans}}{\text{Avg. of all catch cans}} \times 100$$

Emission uniformity

A simple equation to determine the emission uniformity of a drip system is the average discharge of the low-quarter emitters divided by the average flow rates of all emitters:

$$\text{Emission uniformity (\%)} = \frac{\text{Avg. of the low 25\% emitter discharges (volume or time)}}{\text{Avg. of all emitter discharges}} \times 100$$

Stakes are available that can be "turned off" when not in use (left). These emitters, when properly installed, avoid applying water to noncropped areas (right).

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Irrigation uniformity. Irrigation uniformity is an important factor when irrigating plants in containers because the roots of these crops are confined and have a limited volume of growing medium. Therefore, the irrigation system for container plants must be capable of irrigating each individual plant in a uniform manner and not just watering to the driest plant — as most gardeners tend to do. To illustrate, if one side of an irrigation system is applying half the amount of water that the other side is applying, then the entire system will have to run twice as long to ensure that the plants on the low application side are being adequately watered. This leads to overirrigation on the high application side, resulting in runoff.

Improving distribution uniformity (DU) helps to reduce runoff by minimizing the number of plants receiving excessive water when all plants are adequately irrigated.

A good measure. To evaluate irrigation uniformity, all that's needed is a stopwatch, a few catch cans (empty cat food cans will do) and a little time.

Sprinkler system DU can be determined by placing the catch cans in a uniform grid pattern in the irrigated area, operating the sprinkler system and then measuring the amount of water collected in the containers.

The average volume (depth) is calculated by adding the measured amounts and then dividing that number by the number of measurements. One of the most common methods to determine DU is to calculate the low-quarter DU. (See distribution uniformity equation above.) For example, if 20 measurements were used, then the low quarter consists of the five smallest measurements.

After measuring the depth of water in 20 catch cans placed uniformly in an irrigation zone and irrigating for one hour, it was found that the average depth of all the cans was 0.8 inches, and the average depth from the five cans with the lowest depth was 0.6 inches. The calculated DU in this example is 75 percent (0.6 divided by 0.8 multiplied by 100).

Although no irrigation system applies water perfectly uniform, the more you can improve the DU of your system, the more water you will save. Achievable DU depends on the type of sprinkler system, with fixed spray heads typically having a lower DU than those with stream rotors. A low DU (below 60 percent) indicates that application rates are very different, while a high DU (80 percent or higher) indicates that application rates over the area are similar in value and the water is distributed evenly to all the plants.

Microirrigation system irrigation uniformity — emission uniformity (EU) — is determined by collecting a sample from 20 or more emission devices in an irrigation zone and quantifying how much water is delivered by each sampled emitter in a given time — usually 15 to 30 seconds. Dripper flow rates can then be expressed as gallons per hour (gph).

Another method is to quantify the time it takes each emitter to deliver a certain volume. We've found that 35-millimeter film canisters (provided by Kodak, Fuji, etc.) are easy to use for this purpose because they contain nearly 35-milliliters of water when full. In 30 seconds, a film canister will capture the approximate equivalent of a 1-gph emitter.

In our example, after measuring the flow of 20 drippers, it was found that the average flow rate of all drippers was 1 gph; whereas, the average flow from the five with the lowest discharge was 0.9 gph. (See emission uniformity equation at left.) The calculated EU in this example is 90 percent (0.9 divided by 1 multiplied by 100). A system with an EU of 90 percent or greater is operating efficiently, 80 percent to 89 percent is good, 70 percent to 79 percent is fair, and less than 70 percent is poor.

Irrigation audits. Major system maintenance or improvements to an irrigation system should be performed before the crop is in place, on a yearly basis or whenever any major changes are made to the

Using an on/off valve in hand-watering helps save water and prevents runoff.

systems. An irrigation audit consists of determining DU from sprinkler heads or EU from microirrigation devices to quantify irrigation uniformity and to help diagnose problems, such as clogging.

An audit also should include pressure measurements taken at key locations in pipelines and tubings to characterize the system's pressure distribution. Measuring pressure is important because it controls the discharge rate of most sprinklers and many microirrigation emission devices. Operational conditions of the irrigation components, such as valves, gauges and filters, also should be noted. Audits are particularly important in microirrigation systems because they detect early clogging problems.

Audits also provide information regarding any irrigation system changes occurring over time. For example, a decrease in drip-emitter discharge from one year to the next may require a change in irrigation times, but it also may indicate a drop in system pressure or an emitter clogging problem. Additional irrigation audit information should be gathered to explain the emitter discharge decrease and to point to steps to correct the problem.

Outside help. If you are not fond of math, or if you don't have the time or staff to deal with evaluating irrigation system performance, you may find it easier to have your audit done by professionals. Your local cooperative extension, conservation district or natural resources conservation service office may be able to help you with this, or they should be able to point you in the right direction.

For example, in California, the Irrigation Mobile Laboratory (mobile lab) is a service provided by selected resource conservation districts, water districts or water agencies. The mobile lab will visit a farm and evaluate irrigation systems for possible improvements. The basic evaluation consists of DU, although some mobile labs also will evaluate and make suggestions regarding water quality, irrigation scheduling and pumping efficiency.

In addition to irrigation audits, nursery staff should be trained to continuously check for leaks, clogs and missing emitters and tubing to ensure efficient performance of irrigation systems. Replace leaky pipes, washers and hoses, and clean spray heads. Leaks are commonly found in irrigation connections or at the ends of drip tape and feeder lines. Fixing these leaks removes a constant source of water runoff and reduces friction loss and pressure differentials in lines.

Missing emitters and spaghetti tubing allow water to erupt from unplugged holes in the feeder line during each irrigation event. This results in significant water loss and nursery runoff. The remedy is proper installation of components, regular inspection of the lines and the plugging of any holes in irrigation lines. If spaghetti tubing is inserted too far into lateral poly lines, the portion of the spaghetti tube inside the lateral line increases friction loss and reduces the flow capability.

If you have lines that are clogged with mineral calcification or algae, you may see a dramatic reduction in DU. If this occurs, use filters to help prevent clogging. Follow

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the manufacturer's directions for cleaning and maintenance of the drip system. The system can be cleaned with approved algaecides to remove algae buildup. Removal of calcification requires an acid treatment and should only be undertaken when there are no plants present.

Spray patterns of overhead irrigation systems should not create overspray on walkways and edges.

Management practices. The following are examples of management practices that should be used in the nursery to improve irrigation efficiency, conserve water and reduce runoff.

Use trained employees: Assign irrigation duties only to trained employees who know how to carefully monitor plant-moisture requirements. Proper irrigation is not an easy job, yet it often falls to those who are the least experienced. Irrigation training programs for employees are as important as training programs for handling pesticides.

Group plants with similar moisture requirements: Plants and container sizes with similar moisture requirements should be grouped into watering zones whenever possible. Grouping plants that have similar moisture requirements will minimize the overwatering of some plants in order to provide adequate moisture to others.

Check the spray patterns: If you have to use an overhead system, check the spray patterns to ensure that you have the necessary overlap to uniformly irrigate plants. Also, make sure water is applied only to plants and not to nontarget areas, such as roads. Adjustable sprinkler heads that irrigate only part of a circle can be used on the edges of irrigated areas. When using adjustable sprinkler heads, the application rate of sprinklers turning only a portion of a circle is increased. To compensate for this, smaller nozzles can be placed in edge sprinklers.

Space plants directly below overhead irrigation systems to minimize runoff: Position plants as close as possible while still maintaining adequate light for them. This minimizes runoff in the areas between the containers.

Use check valves and shutoff valves: Consolidate plants and shut off irrigation in unused portions, including spray stakes and other emitters that can be "turned off" when not in use. When plants are removed from benches, it's important to shut off unused emitters or replace the current emitters with hoses that have low-pressure check valves. Otherwise, the unused emitters left to hang below benches and pipes will cause water to drain out of the system after each irrigation event. Similarly, using overhead emitters with check valves prevents line drainage and drip damage. Additionally, using an on/off mechanism for hand-watering will help irrigators avoid applying water outside of containers.

Ensure that risers are vertical: When sprinklers are located on pipe risers, the risers need to be kept vertical. The distribution pattern of sprinklers on nonvertical risers is distorted, resulting in lower uniformity.

When possible, avoid sprinkler irrigating under windy conditions: Wind distorts the sprinkler application pattern and leads to lower uniformity.

The comprehensive program. In order to conserve water and reduce runoff, a comprehensive water-management program must be implemented that includes irrigation scheduling and runoff management.

The University of California recently published a manual, *Greenhouse and Nursery Management Practices to Protect Water Quality*, that includes chapters on irrigation and runoff management, contains lists of management practices to conserve water and reduce runoff, and describes how to conduct an environmental audit that includes irrigation-management practices. This manual can be used as a resource for nursery growers to address water-management issues and will be available this winter from the University of California Division of Agriculture and Natural Resources publications at http://anrcatalog.ucdavis.edu/.

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Even a drip system with the potential for high uniformity needs an irrigation schedule based on plant requirements to prevent overirrigation.

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