Testing Irrigation Sprinkler Systems

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Overhead sprinklers are the most common irrigation method in both bareroot and container nurseries. Bareroot nurseries typically use rotary sprinklers that are spaced in some regular geometric pattern. Fixed sprinkler systems are also commin container nurseries, although some have mobile irrigation booms. The spacing of the individual sprinkler heads is determined by the engineering specifications of the nozzle, the water pressure at the head, and anticipated wind speed and direction.

Fixed sprinkler systems have a couple of inherent flaws. All sprinkler heads apply water in a circular area, but there is always some amount of variation from the center of the head out to the outer edge of the circle (Figure 1A). Irrigation equipment manufacturers try to compensate for this by equipping their nozzles with spinners, wobblers, pin points, and so on to their heads to help break up and spread the flow of water. In spite of these engineering features, variation in water application always occurs with the circular application area.

Secondly, both bareroot and container nurseries are divided into rectangular zones or bays that are controlled by a valve. This means, you are attempting to irrigate a rectangular area with a bunch of circles. To demonstrate the difficulty of getting uniform irrigation onto your zones try drawing a bunch of circles within a rectangle so that the surface of the rectangle is covered but no circle overlaps the other (Figure 1B).

Both new and existing irrigation systems should be tested periodically to see if they are performing properly. Many nursery managers assume that a new system will perform according to the engineering specifications, but this should be checked under normal operating conditions. Fischer (1987) found that theoretical irrigation patterns differed from operational patterns and attributes this discrepancy to 2 factors:

1. The theoretical patterns assume that the water pressure will be identical at each nozzle, which is impossible because of pressure losses within the lateral distribution lines.

2. Droplet collision between adjacent sprinklers will affect distribution.

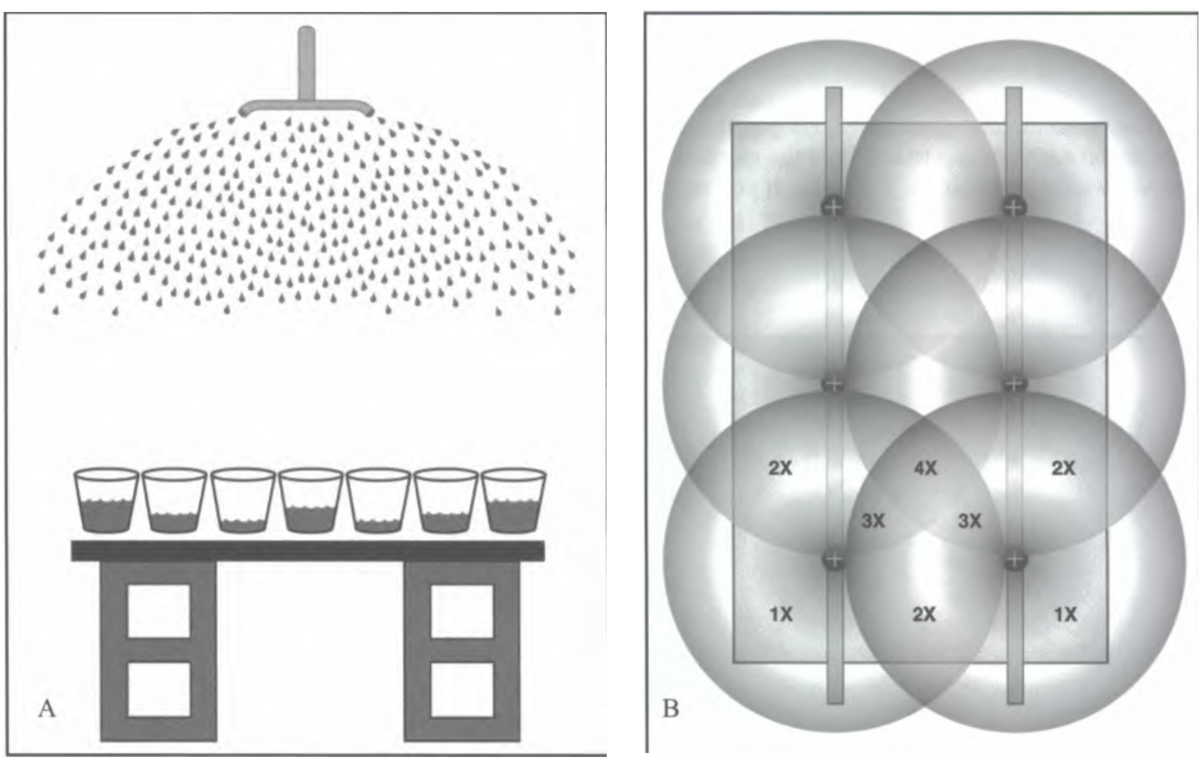

Figure 1—Because all sprinklers apply water irregularly (A), they are installed with considerable overlap which creates application rates up to 4 times as much as normal (B).

Table 1—Target values for measures of sprinkler irrigation uniformity (Savory 2006)

Statistic	Container Nursery	Bareroot Nursery
Coefficient of Uniformity	>90%	>85%
Distribution Uniformity	>85%	>75%
Scheduling Coefficient	1.1	<1.3

Existing irrigation systems need to be checked every few months because nozzles can become plugged or worn down to the point that they are no longer operating properly.

The "Cup Test" - This simple but effective procedure involves measuring the depth of water caught in a series of cups or cans laid out on a regular grid system throughout the growing area (Figure 2). Containers for cup tests should have a circular opening that has a narrow rim; the shape of the container below the opening is not important as long as the cup is stable and deep enough to hold several centimeters of water without any splashing losses. Paper or plastic "Dixie" cups will work but will need to weighted down to keep them in place. Use a standard sized weight like a large metal washer so you don't have to remove the weight before measuring water depth.

Of course, wind direction and speed will greatly affect the results so run your cup test early in the morning or whenever winds are minimal. However, if you must irrigate **during** windy periods, then it will be helpful to run another cup test at the standard irrigation time. Once your grid of cups is laid out, run the irrigation system for a predetermined length of time. Measure the depth of water within each cup and record the values on a chart showing cup placement within the grid (Figure 2B).

Analysis of Cup Test Data

The amount of water collected can be converted to water application rate in inches per hour by the following formula (Furuta 1978):

$$P = (C \text{ x } 3000)i\ (D^2 \text{ x } T)$$

Where:
P = irrigation water applied per hour in inches
C = average water "caught" in cup (milliliters)
D = inside diameter of cup opening in millimeters
T = time of irrigation period (minutes).

Analysis of irrigation efficiency can be high-tech or

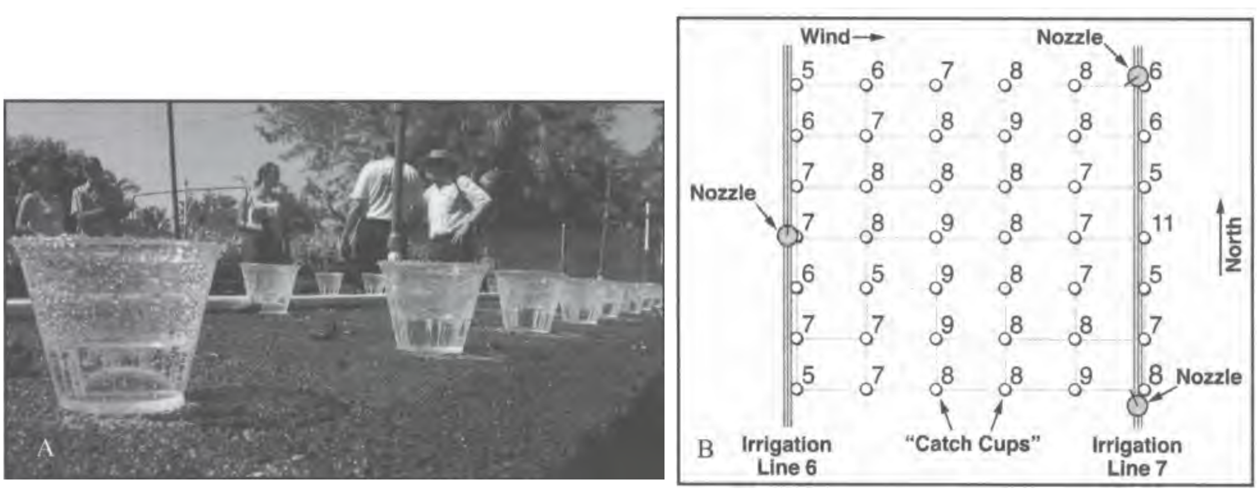

Figure 2—The best way to test irrigation sprinkler efficiency is the "cup test" (A), a regular grid where the depths or volumes of water are measured at each point (B). Photo A by Kim Wilkinson

low-tech. Just looking at the raw collection data will show you where you are over-watering or under-watering. You should also run the cup test values through the standard indices of irrigation efficiency. Target values are provided in Table 1.

Coefficient of Uniformity (CU) - This test, which was originally called Christiansen's coefficient of uniformity, is the most widely used method to evaluate sprinkler efficiency. It is based upon actual measurement of the amount of water collected (the "catch") in the cup test. The CU is a statistical representation of the catch pattern expressed as a percentage, and expresses the average catch minus the average deviation from the average catch to the average catch. Most people measure the depth of water in each cup and calculate the CU as follows:

CU % = 100 (1 - Average Deviation / Average Depth)

Unfortunately, the CU is not a straight-forward measure of the variation within the irrigated area. Because the deviation from the average catch and the catch are both averaged, the full range of deviation between sample individual sample points is not accurately expressed by the CU. This means, if you have a CU of 85%, you can't just increase your watering cycle by 15% to bring the irrigation of the driest points up to the desired level of irrigation. The CU is most useful for evaluating different types of irrigation systems rather than measuring irrigation efficiency.

Distribution Uniformity (DU) - Another common measure of the efficiency of an irrigation system is called the distribution uniformity, and is expressed as a percentage between 0 and 100%. The DU is calculated by dividing the average water depth in the lowest 25% of the cups from the cup test by the average water depth: :

DU % = 100 (Average of Low One-Quarter Readings / Average Depth)

The Distribution Uniformity test can be misleading if the lowest application rates are uniformly spread over the total area.

Scheduling Coefficient (SC) - The scheduling coefficient gives a measure of the additional time required at the area of lowest application (usually measured over 5% of the area) to achieve the average application rate.

A Real World Example

The information in Table 2 is the actual results from a nursery that converted to a new irrigation system. Converting to the new system reduced water application rate and increased irrigation application uniformity in both the greenhouse and the shadehouse. Converting the application rates to yearly water use shows that upgrading your irrigation system can result in substantial savings in water as well as the energy used to pump it. An added side benefit was the reduced amount of water runoff that had to be managed (Messina 2006).

Where to Get Help

Several websites offer help in evaluating irrigation systems. Some offer programs where you can input your cup test data and they will calculate the CU or DU values.

A computer program called SPACE (Sprinkler Profile And Coverage Evaluation) is offered by the Center for Irrigation Technology (CIT) **in** Fresno, California. CIT conducts irrigation equipment testing and evaluation for both public agencies and private businesses and also offer seminars, workshops, study tours and customized training programs for domestic and international clients. Fees for projects are negotiated individually, depending on the type of service and contracting agency. For more information:

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Sources

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