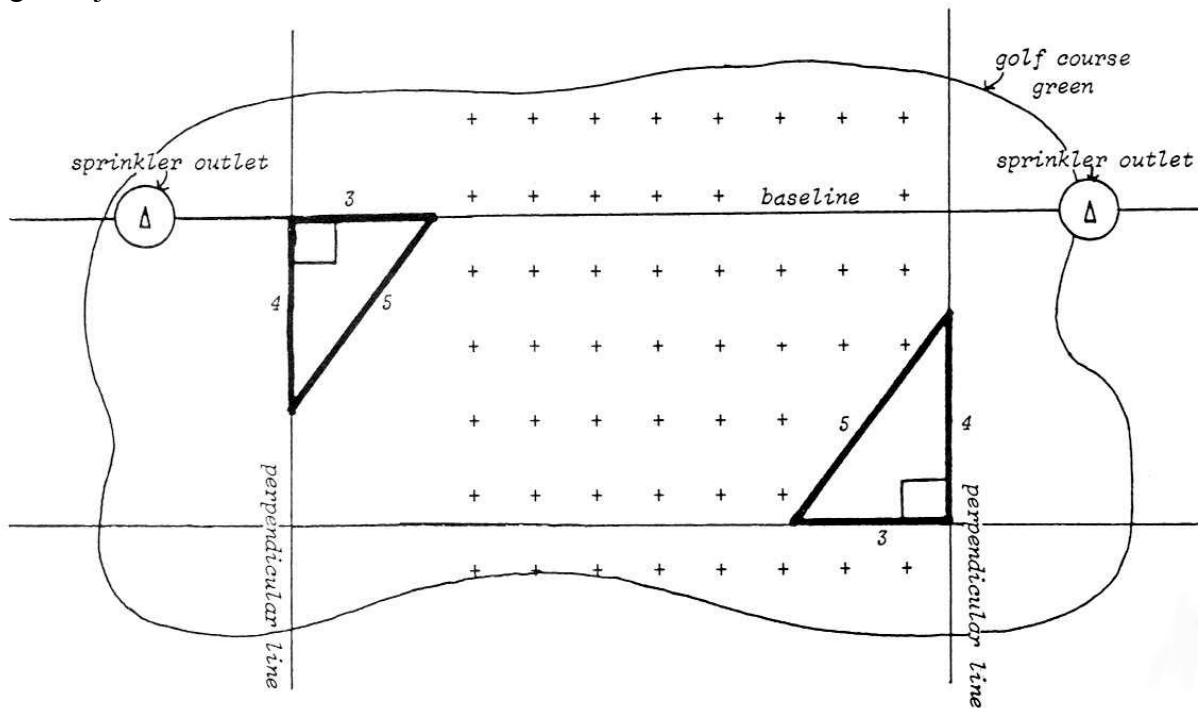


**IRRIGATION PRACTICES:
MEASURING SPRINKLER SYSTEM APPLICATION UNIFORMITY**

Maintaining high quality ornamentals during the summer months is a difficult task. Localized dry areas often occur when available soil or media water is limiting. Drought stressed plants will have reduced growth, leaf drop, tip dieback, and are more susceptible to attacks from insects, disease, and other pests. Water requirements for container-grown ornamentals in the Willamette Valley, Oregon, may reach 170 acre inches per year (Bluhm, 1981). While field-grown nursery stock, ornamental landscapes and turfgrass require less water, irrigation scheduling and system design are just as critical.



Overhead sprinkler irrigation is the most common method of watering ornamentals. The basic objective of sprinkler irrigation is to simulate rainfall and uniformly apply a calculated amount of water at a specific rate (Pillsbury, 1968). Absolute uniformity of applied water is never obtained in irrigation practice. The uniformity of applied water depends on sprinkler spacing, type, system pressure, and wind factors. A result of poor sprinkler application uniformity is uneven soil/media moisture replenishment and is often expressed in distinct patterns. **In addition, when compared**

to good sprinkler system uniformity, a poor system will use more water to irrigate a given area (Shearer, 1969).

Nursery and landscape managers will compensate for poor water application uniformity by overwatering. In doing so, excessive amounts of water will be applied to other areas causing waterlogging, reduced plant vigor, greater disease problems, and increased runoff. Agricultural chemicals applied through irrigation systems will never be more evenly distributed than the water.

The need for nursery and landscape managers to test sprinkler application uniformity cannot be overemphasized. This consists of setting up a grid pattern of rain gauges or catch cans, operating the system for a period of time under normal operating conditions, and measuring the amount of water collected in each can (Pillsbury, 1968).

Catch can measurements are used to determine the uniformity of a sprinkler irrigation system. Christiansen (1942) developed a numerical index representing the system uniformity of overlapping sprinklers. This uniformity coefficient (UC) is a percentage on a scale of 0 to 100 (absolute uniformity). **A uniformity coefficient of 80 is considered by many to be the minimum acceptable performance.** Higher uniformity coefficients are usually needed with intensively maintained ornamentals. Catch can measurements are also used to illustrate water distribution or patterns.

Measuring Sprinkler Application Uniformity

Selecting the proper sample site is critical when measuring sprinkler uniformity. The objective is to select a site that represents both the irrigation system and ornamentals, including patterns of dry and wet areas. Smaller areas such as lawns, greenhouses, or short nursery blocks require complete test coverage, whereas large nursery blocks or golf course fairways are usually only partially covered with catch cans.

An ordinary quart oil can will serve as a catch can. A small amount of residual oil remaining in the can will help suppress evaporation. The surface area of the opened oil can allows it to hold approximately 200 ml of water per inch of depth. Therefore, a reading of 1.0 ml equals about 0.005 inches of applied water. Wire pins attached to the side of the can or an 8 penny nail soldered to the bottom of the can helps to keep the can stationary.

Catch cans are laid out in a square grid pattern that covers the sample site. **As a rule of thumb, the spacing of the cans should be no greater than 10 percent of the sprinkler throw radius.** The most common spacing used for uniformity tests is 5 feet by 5 feet.

The square grid pattern is accomplished by first establishing a baseline that serves as the origin for all catch can placements. For most studies, the baseline is a straight line between sprinklers, on opposite edges of the sample site. Parallel and perpendicular lines to the baseline are established by using the 3,4,5 triangular method (Figure 1). Catch cans are spaced along the lines and the remaining cans are placed using line of sight. Secure catch cans to the ground surface if they are in danger of tipping over.

Operate the sprinkler system under normal conditions. **The operating pressure of the system affects the uniformity of sprinkler application and the amount applied.** If wind speed is greater than 3 MPH test results will be different, often unrepeatable. Operating the irrigation system for the normally programmed time yields direct information on the actual amount of water being applied during the irrigation cycle. Timed intervals of 15 minutes are useful when calculating rates per hour.

Observe the system as it operates and watch for plugged nozzles, improper adjustment, or damaged sprinklers. Time clocks may not operate properly and checking their accuracy with a stop watch is recommended. In one test conducted at a golf course, the sprinklers operated for only 71% to 90% of the programmed time (Table 1).

Collecting the data requires precise measurements. The water in each catch can is measured to the nearest 1.0 ml with a 100 ml graduated cylinder and recorded in a table or directly to scale onto graph paper showing each catch can placement. If graph paper is used, the location of sprinklers should be included for future reference.

TABLE 1. Total operating time of sprinkler outlets during sprinkler uniformity test.

Outlet Number	Actual Operating Time (min:sec)			%*
	1st cycle	2nd cycle	total	
6	7:19	7:00	14:19	71
7	8:00	8:05	16:05	80
8	8:56	8:36	17:32	87
9	9:20	8:40	18:00	90
10	8:00	8:40	16:40	82
11	8:10	8:20	16:30	82

*Each outlet was programmed for a total of 20 minutes.

Calculating the Uniformity Coefficient- UC

Christiansen's uniformity coefficient (UC) is the most commonly used statistical method for evaluating sprinkler system uniformity (Morgan, 1964; Warrick, 1983). Christiansen's uniformity is defined as:

$$UC = 100 (1.0 - x/mn)$$

where "x" is the sum of the deviations of each observation from "m", the mean value of such observations, and "n" is the number of observations. All deviations from the mean are positive numbers. Therefore, any negative number is changed to a positive number. For example: given a mean of 35 ml, and observation of 31 ml would have a deviation of 4 (31-35 = -4 = 4).

Example - Measurements from 15 observations were: 16, 38, 32, 22, 35, 23, 32, 35, 19, 28, 26, 34, 24, 18, 23

$$UC = 100 (1.0 - x/mn), m = 405 / 15 = 27, n = 15, x = 90$$

$$Uc = 100 (1.0 - 90/27X15) = 77.8\%$$

Improving the application uniformity of a sprinkler system can reduce the water supply necessary to irrigate a given area. This savings in water will lower pumping and operating costs. Shearer (1969) showed that the average application required over an entire area to apply at least 1 inch of water on 90% of the area with a UC of 70 is 1.93 inches and 1.19 inches with a UC of 90. **The increase in UC from 70 to 90 would reduce the water requirement for the system by 38.3 percent. With such a savings 62.0 percent more land could be irrigated (Table 2).**

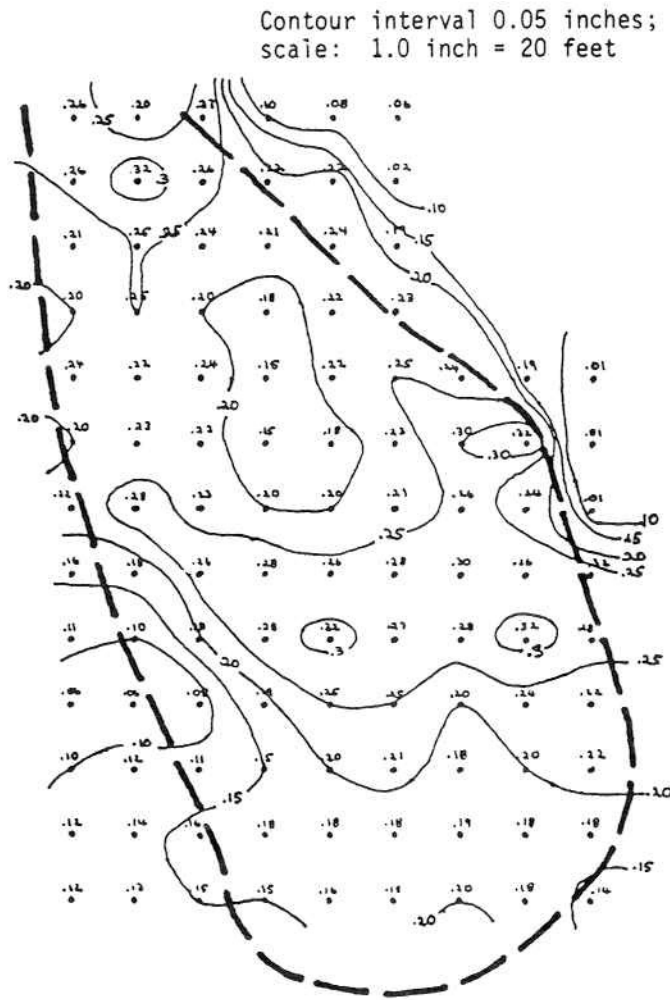
TABLE 2. Effect of coefficient of uniformity (CU) on water requirement as calculated from normal distribution curves.

CU	Water applied over entire area to get at least 1" on 90% of the area. (inches)	Water saved with CU greater than 70 (%)	Greater area irrigated with CU greater than 70 (%)
90	1.19 inches	38.3%	62.0%
80	1.47 inches	23.8%	31.3%
70	1.93 inches	00.0%	00.0%

Illustrating Sprinkler Application Patterns

The application pattern of water from a sprinkler irrigation system can be illustrated on a contour map (see Figure 2). A scaled drawing on graph paper showing the placement of catch cans, sprinklers, and growing area is used. Field data from each observation is converted from ml to inches of applied water. Measurements taken from quart oil cans are converted to inches by multiplying the total water collected in ml by 0.005. Values are recorded directly onto the scaled drawing as either inches of applied water per irrigation cycle or rate in inches per hour.

FIGURE 2. Sprinkler system application pattern for a golf course green or nursery production area.



Contour lines are used to show the gradients or patterns if applied water. Contour intervals for most studies range from 0.1 to 0.5 inches. When completed this drawing will show application patterns and define potential problem areas related to dry spot or overwatering. Computer programs are being used to calculate UC and illustrate application patterns (Trimmer, 1986).

Interpreting The Results

If the UC is lower than 80, steps should be taken to redesign or modify the irrigation system. Major adjustments are usually accomplished by the addition of sprinklers or changing sprinkler spacing. However, this type of change can significantly change the performance of irrigation pumps. Sprinklers that are added to the system need to be positioned carefully. In placing a sprinkler to correct a low water area another may become overwatered.

Use the application pattern map to locate a temporary sprinkler and retest the uniformity again before installing it permanently.

Since the operating pressure of the system was determined when it was designed, increasing or decreasing the pressure to improve uniformity is useful only when it has deviated from the design. Changing the nozzle size is useful when making only minor adjustments to the system.

Correcting irrigation systems with poor application uniformity requires special considerations, especially economic aspects. **Although initial costs are important, annual costs per acre compared to annual returns per acre are the best measure of the economics of an irrigation system (Israelsen, 1962).** Consider application uniformity a necessary design parameter before installing a new irrigation system. Also, regular sprinkler maintenance and repair are important aspects to good irrigation practices.

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