Northeastern Forest and Conservation Nursery Association Meeting

Grand Rapids, Michigan

July 20 to 23, 2009

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Determining Irrigation Distribution Uniformity and Efficiency for Nurseries

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Fernandez RT. 2010. Determining irrigation distribution uniformity and efficiency for nurseries. In: Riley LE, Pinto JR, Dumroese RK, technical coordinators. National Proceedings: Forest and Conservation Nursery Associations—2009. Proc. RMRS-P-62. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station: 64-66. Online: http://www.fs.fed.us/rm/pubs/rmrs_p062.html.

Abstract: A simple method for testing the distribution uniformity of overhead irrigation systems is described. The procedure is described step-by-step along with an example. Other uses of distribution uniformity testing are presented, as well as common situations that affect distribution uniformity and how to alleviate them.

Keywords: water management, water conservation

Introduction

Water availability is becoming a critical issue to the ornamental plant industry nationwide, even in regions thought of as water-rich. Competition for water resources, increased legislation, and recent droughts are all increasing the need for ornamental crop producers to manage water more effectively. Additionally, significant losses of fertilizers and other agricultural chemicals, such as pesticides, can occur due to misapplication. Runoff water created by misapplication and over-application can transport these chemicals to containment ponds and/or off-site into groundwater or surface water (Camper and others1994; Briggs and others 1998, 2002; Cabrera 2005). Irrigation water management is a key component in reducing the impact of runoff water on surrounding water resources and in nutrient management in ornamental crop production (Tyler and others 1996; Lea-Cox and others 2001). Improving irrigation efficiency and uniformity will reduce misapplication and over-application, improve plant production, and possibly reduce costs. There are some very simple procedures that any nursery can do to evaluate and improve their irrigation systems.

Determining Overhead Irrigation System Distribution Uniformity

Distribution uniformity (DU) is a term used to express water application uniformity. The higher the DU, the more uniform the water application. A low DU, below 60%, indicates unequal distribution of irrigation water, while a high DU, over 80%, indicates water is applied fairly evenly to all the plants in the irrigation zone. Irrigators should attempt to have DU over 80%, especially for container production where gaps between containers decrease irrigation application efficiency. Field evaluation of DU is simple and should be done annually.

It is important to determine the DU of irrigation systems, because a higher uniformity of water application results in more similar delivery of water to all plants within an irrigation zone. Water use efficiency increases as water application uniformity increases. Low DU of an irrigation system will result in either over-watering of some plants in order to provide sufficient water to others, or under-watering of some plants in order not to over-water others.

Testing DU for overhead irrigation systems is easy to conduct and requires no special equipment. A minimum of 16 rain gauges or 16 straight-sided catch containers and a ruler are the only necessary pieces of equipment. As long as the cans are straight-sided, they can be of different types (width or height). More than 16 gauges/cans may be used, but should be kept to multiples of 4; it will make the math easier. Distribute the gauges/cans evenly throughout the irrigation block to be tested as shown in Figure 1. Place gauges/cans so that they are not all in the same proximity to lateral lines; for example, do not place them all directly in the middle of lateral lines or in line with laterals (Figure 1). In a large irrigation block, test several areas within the irrigation block. As was done for location of gauges/cans, do not locate all test sites in line with each other; rather locate them so different sets of lateral lines are tested. (See example in Figure 2.) Run the irrigation system for at least 1 hour, or for the duration of a normal irrigation cycle. Measure the depth of water in each can and record it. The average application rate for the block is the sum of all the depths divided by 16. For the example using Figure 1 and Table 1, the application rate is 21 mm/hour (0.8 in/hour). To determine the DU, use the lowest quarter of the measurements and calculate the average of those readings. For the example, (5 +5 + 5 + 5) / 4 = 5 mm [(0.2 + 0.2 + 0.2 + 0.2) / 4 = 0.20 in]. DU equals the lowest quarter of the measurements divided by the average application rate times 100, that is, (5 / 21) x 100 = 24%.

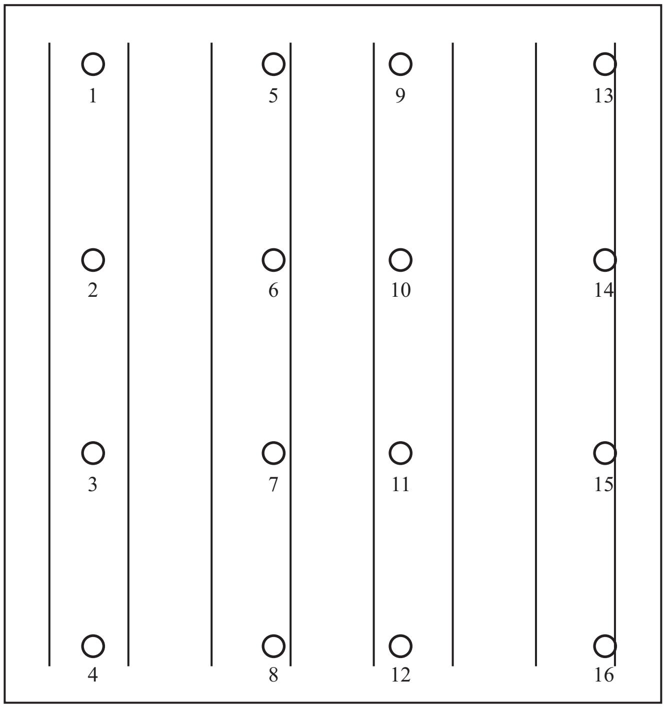

Figure 1. Layout example for rain gauges or catch cans for determining irrigation distribution uniformity in a small (0.4 to 1.2 ha [1 to 3 ac]) irrigation block. Lines denote lateral irrigation lines and circles denote location of rain gauges or catch cans. The numbers below the circles are for identification of the location of the gauges or cans to assist with trouble-shooting.

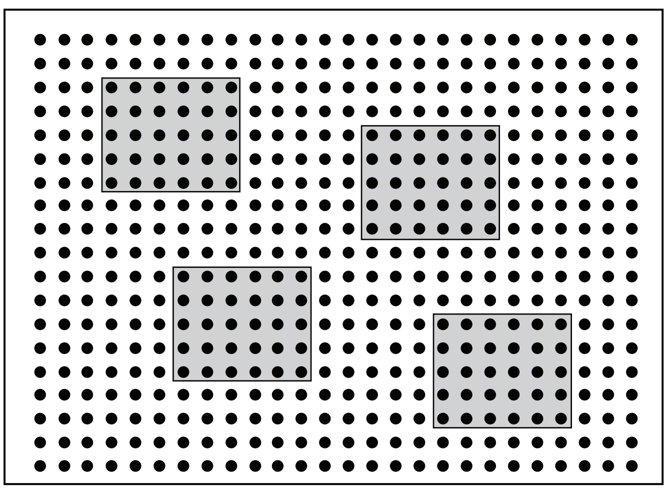

Figure 2. Layout example for determining distribution uniformity (DU) within a large irrigation block (greater than 1.2 ha [3 ac]). Black circles denote irrigation heads. The small squares denote suggested areas to measure to determine DU. DU tests should be conducted in each area using 16 rain gauges or catch cans to better determine DU of the large block.

It is useful to know the location of gauges/catch cans to assist in troubleshooting. In the example, the DU was very low, 24%. The 4 lowest measurements were gauges 5 to 8, all along the same lateral line. This may indicate a problem with that lateral, perhaps a crack in the line or something clogging the lateral. Examine the line for problems, fix any found, and rerun the test. It is also useful to record the time the irrigation system was run; this will allow determination of the application rate. In the example, the system was run for 1 hour and 15 minutes (1.25 hours). The application rate is the average of all gauges/catch cans divided by the run time, 21 mm/1.25 hour = 17 mm/hour (0.8 in /1.25 hours = 0.7 in/hour).

Table 1. Example of catch can water levels corresponding to the catch can layout shown in Figure 1.

Catch can number	Height of water in catch can in mm (in)
1	28 (1.1)
2	25 (1.0)
3	23 (0.9)
4	23 (0.9)
5	5 (0.2)
6	5 (0.2)
7	5 (0.2)
8	5 (0.2)
9	25 (1.0)
10	28 (1.1)
11	22 (0.9)
12	24 (1.0)
13	29 (1.2)
14	33 (1.3)
15	23 (0.9)
16	28 (1.1)
Average all catch cans	21 (0.8)
Average lowest quarter catch cans	5 (0.2)
DU (Avg lowest ¼ / avg all) x 100	24 %
System run time	1 hour 15 minutes (1.25 hours)
Application rate (avg all cans/system run time)	17 mm/hour (0.7 in/hour)

Several factors can cause a poor DU, some of which are easy fixes and others that are more difficult. The easier fixes are:

1) Inadequate irrigation system operating pressure for the nozzles being used. Sprinkler heads come with pressure specifications regarding pattern and distribution, usually a fairly large range. If the pump is supplying too much or too little pressure, the nozzles will not perform properly. Adjusting the delivery pressure at the pump will solve this problem. If the pump pressure has to be high to supply other irrigation blocks, in-line pressure reducers can be used and are inexpensive. If the pump pressure cannot be increased further, the irrigation block is too large and can be split into smaller blocks.
2) Improper selection of nozzles. Instead of adjusting the pump pressure, different nozzles can be selected with pressure specifications that fit what the pump delivers. Also, all nozzles within a block should ideally be from the same manufacturer with the same distribution patterns (that is, the same model).
3) Changes in system components over time. Nozzles wear out; pumps become less efficient; pressure regulators fail. Proper maintenance is essential and components should be serviced or replaced when they no longer meet specifications. Nozzles are the easiest

and least expensive to replace, and will change more rapidly than other system components. Use a drill bit of the same size as the nozzle opening to check for nozzle wear. The bit should fit snuggly in the nozzles. As nozzles wear, the fit will become poor and the nozzles should be replaced. Nozzles can become clogged by mineral deposits. If the bit can no longer be placed in the nozzle orifice, then the orifice should be cleaned.

4) Clogged nozzles. In addition to mineral deposits, nozzles get clogged with a variety of objects from stones to insects. Usually you can easily see what is clogging the nozzles, and it is easy to remove the item with a wire or by taking the nozzle off and cleaning it.
5) In-line filters. Some of the smaller overhead nozzles have filters just before the nozzle. These need to be cleaned regularly.
6) Wind. Irrigation systems should be designed with regard to prevailing winds. Increasing the amount of head-to-head overlap can increase DU for established systems that were not properly designed for prevailing winds.
7) Improper selection of pipe diameters. This is the most expensive mistake to remedy. Replacing above-ground pipe is relatively inexpensive, but replacing buried pipe is costly. In some cases, minor changes in system design can solve the problem.

Summary

Testing DU is the first step in improving the overall efficiency of irrigation systems. Determining DU can not only improve irrigation efficiency, but can assure adequate irrigation is reaching all plants in an irrigation zone, assist with trouble-shooting, and determine actual irrigation application rate within irrigation zones. Spacing, timing, duration, rate, and several other factors also need to be considered when trying to improve irrigation efficiency, but DU is one of the most important factors and easiest to determine.

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