How uniform is coverage from your irrigation system?

Corrections can be made so that almost any irrigation system will provide more uniform coverage while using less water.

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"You never miss your water 'til the well runs dry." Every golf course superintendent wants water available for irrigating turf. Until faced with mandatory water restrictions during times of drought, superintendents, like most people, often take water for granted. When times are dry and limitations are put on how often and how long the irrigation system can run, the effects of a nonuniform distribution of the limited water resources may become obvious. Most superintendents probably do not consider the uniformity of the irrigation system when rainfall is adequate or when irrigation run times are not restricted.

What is distribution uniformity?

Distribution uniformity is a measure of irrigation efficiency defined as the ratio of dry areas to wet areas, and it may be expressed as a decimal or a percentage. Quite often the terms *uniformity* and *efficiency* are used interchangeably, but they have different meanings. *Efficiency* is the ratio between how much water the plant beneficially uses compared to how much water is being applied. *Uniformity*, however, relates to how uniformly water is made available to plants over an area (Figure 1). Uniform irrigation water application is important to maintain uniform appearance of turfgrass.

The research

In 2002, we began to evaluate irrigation systems for uniformity as part of a grant from the St. Johns River Water Management District. On five golf courses in central Florida, we evaluated distribution uniformity on tees, fairways and greens independently on three randomly chosen holes on each course. These irrigation systems were less than five years old and represented equipment from two of the most commonly used manufacturers. These golf courses were picked at random in an attempt to use representative installations of the systems.

Methods

What has been called "catch-can" auditing is the best method to determine actual system performance. (Hereafter, we will refer to it as *catch-container* auditing because the method does not actually use cans.) A series of collection containers are spaced uniformly in a specified area.

For this study, catch containers were placed on tees, greens and fairways in a grid pattern. The spacing was 30 feet on center for fairways and 10 feet for tees and greens (Figures 2,3). Each irrigation zone was run for 30 minutes. The systems were tested at night to minimize wind distortion. Wind speed during testing was always less than 8 mph. Volume in each collection container was measured and recorded (Figure 4). Distribution uniformity can be calculated from the collection data.

KEY points

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- **An irrigation system** with properly placed heads and correct pressure provides more uniform coverage.
- **Uniform coverage** results in healthier grass and lower water usage.
- **A "catch-can" test** coupled with use of a mathematical formula and recommendations from the irrigation manufacturer can help superintendents achieve more uniform water coverage and reduce water use.

Calculating distribution uniformity

Distribution uniformity is calculated in several ways, but the method most commonly used for golf course systems is called the Low Quarter Distribution Uniformity or DU_{lq}. Catch-container data are summarized into one value using the DU_{lq} equation. A DU_{lq} of 100% would mean that the entire area received exactly the same depth of water.

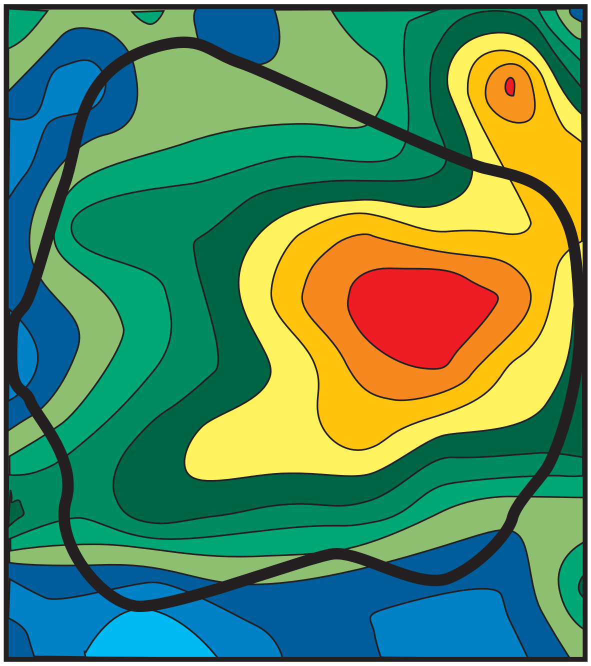
$$DU_{lq} = \frac{Avg.\ LQ}{V_{avg}} \times 100\ ,$$

where DU_{lq} = lower quarter distribution
$Avg.\ LQ$ = Average of lower 25% of sample
V_{avg} = Average catch-container volume for test group.

Achieving uniformity

Because of sprinkler design, head layout, system design and installation, and environmental influences, 100% uniformity is not possible to achieve in actual field conditions. Most irrigation systems have average DU_{lq} values between 55% and 75%. The Irrigation Association has set a DU_{lq} of 80% as achievable for golf courses and rates a system that achieves that number as excellent. A reasonable expectation is a DU_{lq} of 70%; anything less than 55% should be analyzed to see why the distribution is so poor.

Another benefit of a catch-container test is the ability to determine the precipitation rate (PR) for the areas being tested. This information is useful for scheduling accurate



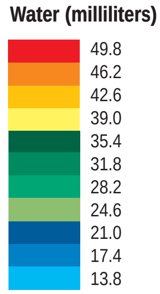


Illustration courtesy of Grady Miller

Figure 1. This diagram shows the water distribution on a golf green. The heavy black line indicates the edge of the green.

run times for irrigation system zones.

The central controller uses PR and flow data to determine run times. Precipitation rates are usually provided by the manufacturer and are based on several assumptions. Unfortunately, the system is probably operating under different conditions from those assumed at the time of installation. The catch-container test data will provide real numbers so that the controller can be set appropriately.

Other parameters

In addition to evaluating performance of the irrigation systems, we monitored climatic conditions, soil type and condition, and turf water needs in this study. These data will later be used to model water needs with the intention of better refining the water-allocation procedures used by the water management districts. We hope to validate current practices by evaluating conservation schedules, which were developed for particular holes on each golf course. These conservation holes can then be used to determine whether less water resulted in any disadvantage to the turfgrass.

Discussion

Unfortunately, it is easy to forget about conservation when water is readily available and inexpensive. In Florida, water use is regulated, but the cost is still low. If water is drawn from an on-site water source (lake, pond or well), the golf course may not incur a direct cost, but indirect costs, such as pump electricity and wear and tear on irrigation system components, should be considered.

Public perception of water use may be the most significant benefit from water conservation. When it regularly observes rows of irrigation heads shooting out 80-foot streams of water, the nongolfing community — and sometimes even the golfers — target the golf course as wasting water.

Uniformity = savings

In this study, the average DU values were 57% for tees, 50% for fairways and 60% for greens over the five golf courses evaluated. Low DU_{lq} values can have a large impact on water use.

The following example uses the average DU_{lq} value of 50% for fairways to calculate the irrigation water requirement. If 50 acres of turf on the fairway of one golf course require 13.8 inches of water per year, then the superintendent actually applies 19.7 inches of water to make sure the turf in the areas with the poorest uniformity receive adequate irrigation. This results in overwatering some areas of the fairway. If the entire system has a uniformity of 60% (like the average of the greens), then the system only needs to apply 18.2 inches of water. At the expected DU of 70%, only 16.8 inches of water need to be applied. In terms of gallons of water, the difference between 50% and 70% over 50 acres of fairways is close to four million gallons.

The reduced amount of water needed with an improved DU translates into less time needed to pump water. Lower pump

Photos courtesy of Grady Miller

Figure 2. For a catch-container audit, containers are placed in a grid pattern as shown here on a golf course green and fairway.

Figure 3. A catch-container test is set up on a tee area.

times translate into lower electricity costs and less wear and tear on the system. These costs can easily be calculated based on electricity costs and pump station output (gallons per minute). The result is a significant financial impact over the course of a year or over the life expectancy of the pump station.

If the water is from a municipal source, a large cost savings would be expected from reduced water bills. The costs to improve sprinkler uniformity may be covered in the first year and result in a positive impact on the course's condition and the public's perception.

Improving the system

Improvement of the system is often easy. Checking the DU can highlight specific weaknesses and opportunities for improved irrigation. In our study it was not uncommon to find the obvious problems such as tilted heads or heads that are below the soil line. Heads should be monitored for missing or broken nozzles, leaks or improper rotation. Reduce the interference by turf and other objects. Usually an accumulation of these minor problems contributes to low uniformity. Most of these improvements can be made if the system is periodically operated during the day while maintenance personnel look for obvious problems.

After these corrections are made, the next steps may be a little more time-consuming. The irrigation design should allow for good flow and head-to-head coverage, which are influenced by three things: pressure, flow and spacing. Pressure is affected by a number of factors, including pump station, pipe sizing, friction loss, valves, the number of nozzles per zone, nozzle size and leakage.

If pressure problems are diagnosed, appropriate adjustments are important and may be as simple as altering the watering schedule or changing nozzles in a head. The nozzle selection and operating pressure determine sprinkler spacing. The manufacturer's specifications can be helpful in fitting the proper nozzle and pressure given the spacing of the heads.

The irrigation system should be treated similarly to other pieces of equipment. Like turf maintenance equipment, irrigation system components need to be maintained at regular intervals to operate effectively and efficiently. Auditing the system on a regular basis provides the capability to track and quantify the historical performance of the system. Observing these data over time permits better scheduling and budgeting for irrigation system maintenance and upgrades.

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References

1. Allen, R.G., L.S. Pereira, D. Raes and M. Smith. 1998. Crop evapotranspiration: Guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper 56. Rome, Italy.
2. Irrigation Association. 2003. http://www.irrigation.org (Verified June 12, 2003.)

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Figure 4. University of Florida graduate students Nick Pressler (left) and Mark Mitchell use a graduated cylinder to measure catch-container collection volumes on a golf green.