Comparison of Water Application to Turfgrass Utilizing Different Irrigation Equipment

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Abstract
This small study and demonstration was established in 2006. The purpose of the study is to measure the amount of water applied to the tall fescue turfgrass by sub-surface drip irrigation (SDI) compared to traditional pop-up spray head irrigation. Each plot is a mirror image of the other with straight edges, sharp angles and curved borders. One plot has pop-up spray heads with its own valve and water meter. The other plot uses in-line drip emitter tubing evenly buried and spaced throughout the area with its own valve and water meter. The irrigation for each plot is controlled by the use of soil moisture sensors which determines the frequency and duration of irrigation events. The results provided are for the 2007 growing season.

Background
The plot of ground where the study and demonstration is located is at the Conservation Gardens of Northern Water located in Berthoud, Colorado. The soil type is a clay / silty-clay soil. The turf plot was prepared by deep tilling (150-300 mm) five cubic meters of composted organic matter per 100 square meters into the existing disturbed soil. The turf-type tall fescue grass was established from seed that was planted in July of 2006. The area was divided in half so that each plot had approximately 130 square meters as shown in the diagram.

One half of the plot was irrigated with traditional pop-up spray heads with a built-in pressure regulator set for 207 kPa. The majority of the nozzles were fixed arc and difficult angles utilized adjustable-arc nozzles. Because of the geometry of the area, a mix of nozzles were installed into the spray heads. A catch-can test was performed to measure the lower-quarter distribution uniformity and the result on the date of the test gave a DU_{LQ} of 68%.

The subsurface drip irrigation utilized drip emitters that were 1.0 lph with the emitter spacing being 460 mm on center in the 12 mm tubing and the tubing lines were installed 380 mm on center buried 125 mm below the soil level. Tubing was carefully installed and measured to have a constant depth of bury and spacing between the lines and so that the emitters were in a triangle pattern as much as possible.

Each plot had its own valve and water meter. The irrigation events were controlled with a soil moisture sensing system. The water source for the spray heads utilized water from a holding pond and pump station. The window of opportunity to irrigate was every other day between set hours that would not conflict with the other sprinkler zones that were supplied by the pump station over the course of the season. Hours for irrigation were set for night watering with maximum run time of 10 minutes per cycle with a 30 minute soaking period. The soil moisture controller system would determine the number of cycles to irrigate to maintain soil moisture between upper and lower thresholds which are based upon soil type. During peak water demand parts of the season the every-other-day watering would mean there was about a half-inch deficit in soil moisture depletion. However, irrigation would not occur if the minimum threshold for soil moisture had not been reached. When this happened because of cooler weather or rainy periods the frequency of irrigation was automatically stretched out. Because of pump-station capacity, there were fixed limitations on when irrigation could take place and sometimes the soil moisture deficit could be greater than the desired 50% managed allowed depletion, but that was rare.

For the sub-surface drip irrigation the source of water was from a municipal supply. The time for irrigation was set for 1 p.m. each day, again utilizing a cycle and soak method of 20 minutes of irrigation and 20 minutes of soak time. The upper and lower thresholds for soil moisture were set in the soil moisture controller system. The concept is for irrigation to initiate when the lower threshold for moisture was reached and stopped when the upper threshold of soil moisture was reached. The thresholds are determined by soil type and management decisions on what the managed allowable depletion should be.

The goal was to have very nice looking grass. Mowing took place usually twice a week with a mowing height of three inches. Fertilization used an organic-based fertilizer with 7% nitrogen with 2 applications for the season. Each application was applied at 0.7 kg of Nitrogen per 100 square meters.

An on-site weather station collected the weather data on 15 minute intervals and the ASCE Standardized Penman-Monteith Evapotranspiration equation was used to calculate reference ET for grass or ET_O. ET values were calculated from midnight to midnight each day.

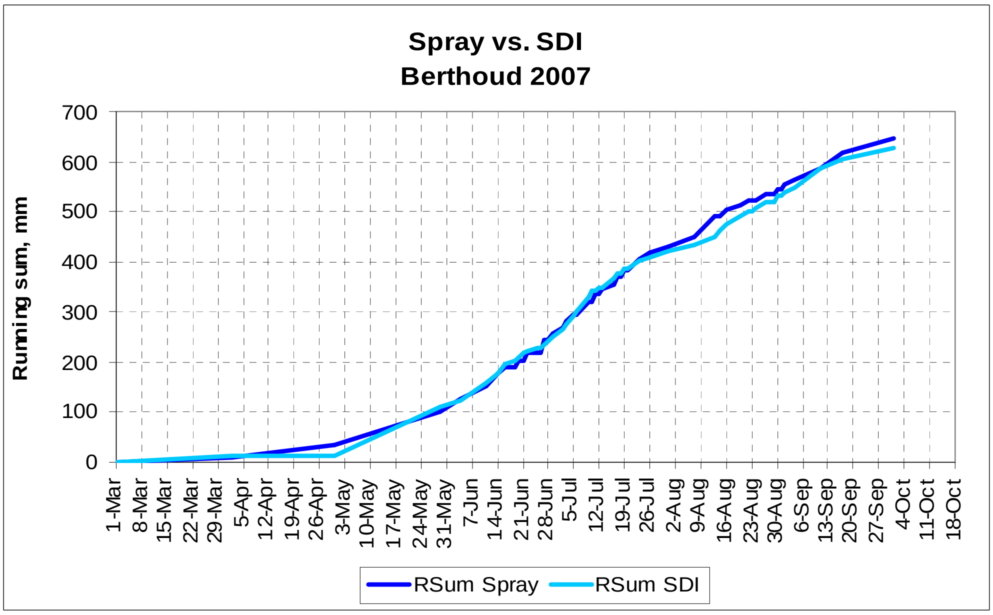
Picture 1 shows the general configuration of the test plot. It was divided in half so that each part of the plot was a mirror image of the other. The foreground of the photograph is the location of the pop-up spray heads. The sub-surface drip is toward the back. This photograph was taken in October of 2006, 3 months after the initial seeding.

Results

The results for 2007 cover the period of March 1 through September 30. By allowing the soil moisture sensors to control the irrigation, essentially the grass irrigated itself without human management making changes to the irrigation schedule other than to set the schedule based on site specific requirements and limitations. Once set, the schedule was left alone. The water meters for each plot were read at least weekly and during the hottest part of the growing season when irrigation would be the greatest, the meters were read almost daily.

Figure 1. shows that the two different application methods applied nearly an identical amount of water over the period. The spray zone applied 647 mm and the sub-surface drip irrigation system applied 626 mm which is about a 3.5% difference which could be within the tolerance of water meter accuracy.

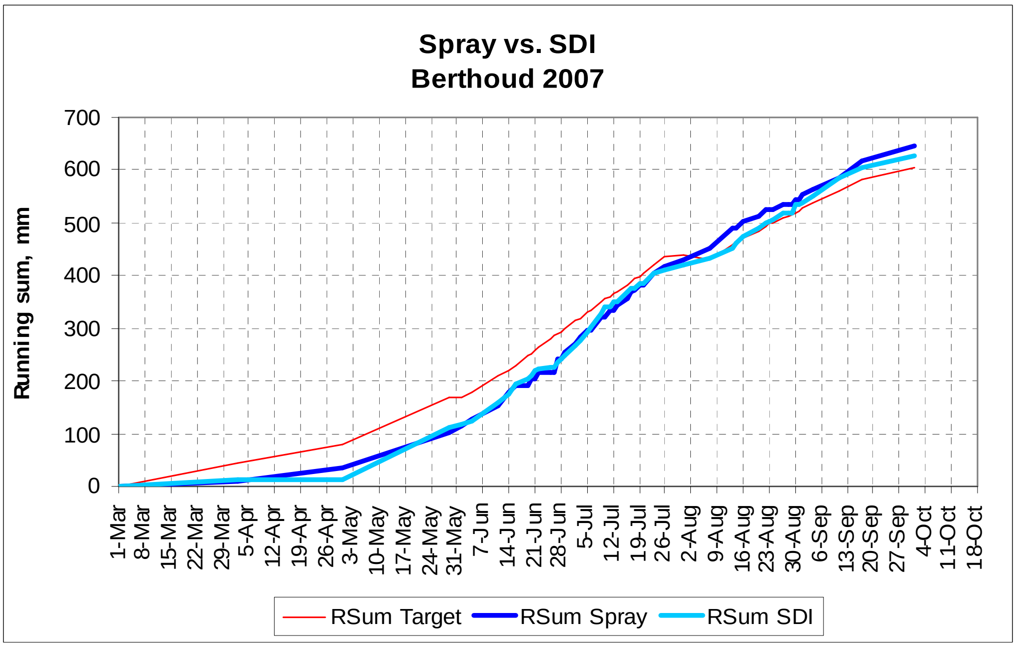
Figure 1.



The reference evapotranspiration (ET_O) for the period was 985 mm and site rainfall for the period was 365 mm. Sufficient rainfall fell in March and April that the irrigation systems were not activated until late April which is fairly typical for the region

Figure 2 is a graph that shows the amount of water applied compared to the target amount of water for the same period. The target amount of water was calculated by adjusting the ETO by a .80 a crop coefficient subtracting 50% of the rainfall. A running sum was created by converting the number of gallons recorded from the water meters into inches so it could be compared to the target inches of water. As will be noted, the target amount seems to be somewhat high early in the season and slightly low at the tail end of the season. The dip in the early part of the season makes sense as the grass is coming out of dormancy and the full amount of water as calculated by ET equations is not actually needed by the turfgrass.

Figure 2.



Figures 3 and 4 are for examining the results of water applied compared to reference ET and striving to identify the target amount of water that should be applied. The comparison is now for the period of greatest water demand in the area of June, July and August which is fairly typical of most regions in North America. Depending on the crop coefficient use, the results and conclusions can change. Figure 3 is utilizing the .80 crop coefficient as used in the previous graphs and it would seem to indicated the water applied is greater than the need. However, the modifier is one commonly used with a number of equations when striving to make irrigation schedules. Figure 4 utilizes a .90 crop coefficient which would be similar to literature that is published for using the Standardized Penman-Montetih Reference ET equation for a well cared for cool season turfgrass. When looking at this graph then the water applied matches closely to the target amount of water estimated.

Figure 3.

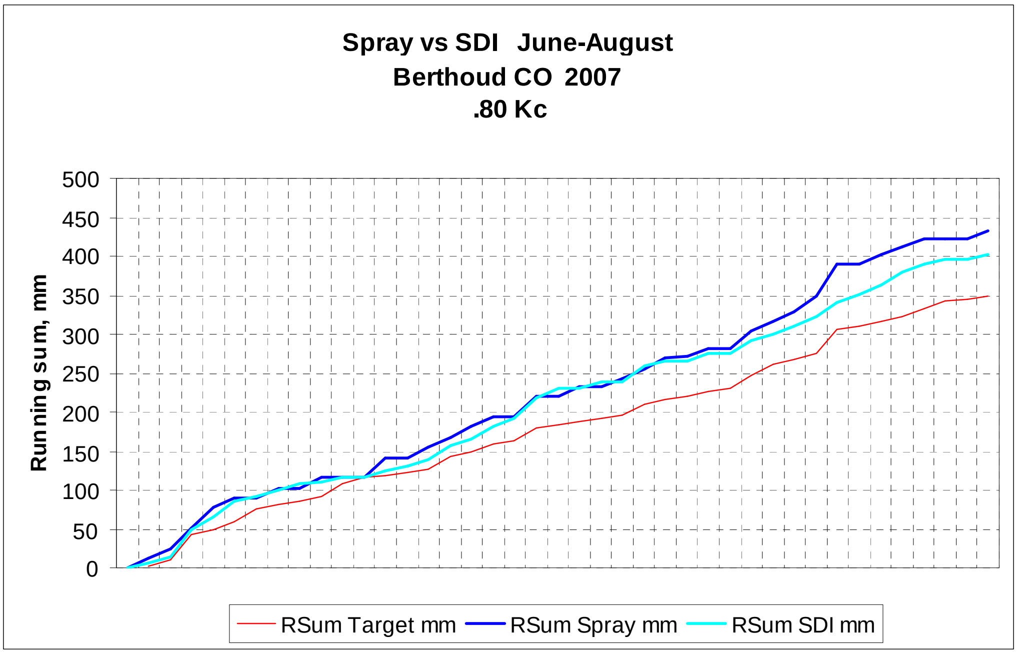
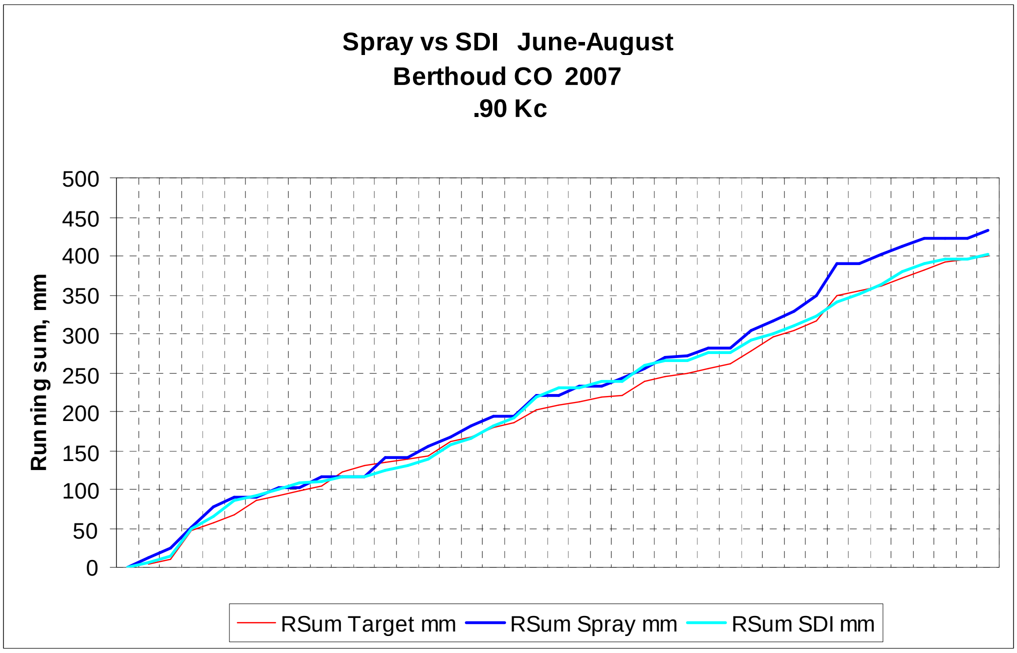


Figure 4.



Observations

By looking at Figure 4 one might make the conclusion that the SDI zone was applying the right amount of water and that the Spray zone applied too much water. However, visual observation toward the end of the season showed that the turfgrass growing in the SDI plot was showing stress and was actually under-irrigated and that the grass in the spray head area appeared better. This would then be an indication that even the .90 crop coefficient may under-estimate the amount of water required. This actually shows some of the challenges in scheduling irrigation in urban landscapes because of the many variables that influence the amount of water required including the type of horticultural maintenance taking place.

The amount of water applied showed that the grass needed that amount of water and did not care in what manner the water was delivered. It could be argued that with over-head irrigation you have the challenge of keeping all of the water on the target and we know that frequently it is blown off-target by Mother Nature. SDI does not have this problem, but because it is below grade, the waste may not be obvious because it would take the form of deep percolation, water going deeper than the roots can acquire and use.

No extra water was allowed because of distribution uniformity issues. While the pop-up spray zone had very acceptable uniformity, it is difficult to measure uniformity of sub-surface drip irrigation. Usually that is done visually when stripping or numerous hot spots appear in the turf. In both plots we could observe hot spots develop.

Some important observations can be noted.

1. Uniform soil conditions are essential for SDI to be effective.
2. Better performance of SDI is achieved by irrigating in the heat of the day which is often contrary to many recommendations. SDI depends upon the capillary movement of water to uniformly wet the soil profile. The capillary movement of water is greatly enhanced during periods of active evapotranspiration. This helps minimize the stripping effect that is often associated with the use of sub-surface drip irrigation.
3. Crop coefficients are general in nature and not specific for a species of grass and the associated horticultural practice utilized in caring for the grass. More research is needed to help identify crop coefficients that may change during the growing season as grass goes through growth phases.
4. Proper design, installation, maintenance and management have big impacts upon how much water is used to get desired results. Proper application to irrigation methods and technology will get better results. This is not new news, but it is yet fully practiced and embraced.
5. Trying to establish seed using SDI did not work and supplemental over-head irrigation was needed.
6. Watering in fertilizer is easily achieved with spray heads, but needed a timely rain to active the fertilizer on the SDI plot.

Conclusions

This is the first year of a study that needs to be repeated for several more years before conclusive results can be identified. Until then, the moral of this story is that grass wants its water and it doesn't care too much how it gets delivered, spray, SDI or rainfall.