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Utah State University researchers found that irrigating turfgrass on a 2-day cycle resulted in higher average turf quality than turf irrigated on 4- or 6-day cycles throughout the growing season. However, they caution that 2-day-cycle turf is more vulnerable to drought stress in the event of irrigation delays.

Volume 2, Number 6
March 15, 2003

PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 215 projects at a cost of $21 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

Editor

Jeff Nus, Ph.D.
904 Highland Drive
Lawrence, KS 66044
jnus@usga.org
(785) 832-2300
(785) 832-9265 (fax)

Research Director

Michael P. Kenna, Ph.D.
P.O. Box 2227
Stillwater, OK 74076
mkenna@usga.org
(405) 743-3900
(405) 743-3910 (fax)

The Influence of Frequent or Infrequent Irrigation on Turfgrasses in the Cool-arid West

Paul G. Johnson

SUMMARY

Most turfgrass research has shown that irrigating deeply and infrequently is best for overall turfgrass health. However in the arid West, a region of warm to hot summers and low humidity, frequent irrigations may result in water savings and no loss in turfgrass quality. We studied four turfgrasses (Kentucky bluegrass, tall fescue, prairie junegrass, and buffalograss) at three irrigation frequencies, every 2, 4, or 6 days with 70% of ET_0 replacement.

- Overall, the turfgrass quality of the 2-day interval was better than the 4- and 6-day intervals, however, differences varied from year-to-year. The 2-day interval provided a very consistent level of soil moisture over time.
- Soil and thatch layer temperatures in the 6-day interval plots experienced increasing temperatures each day, prior to an irrigation event compared to more consistent temperatures in the 2-day treatment. However, 2-day interval plots were consistently warmer in many time periods.
- Although the quality was higher in the 2-day plots, the turf is more vulnerable to drought stress in the event of irrigation delays. A schedule of infrequent and deep watering, possibly on a 6-day schedule combined with a light irrigation daily or every other day may be a good compromise.

In turfgrass management we use similar grasses and even the same varieties over wide-ranging environments across North America and the world. However, management of these grasses can be quite different in various parts of the country. This appears to be the case with irrigation of cool-season grasses in the semi-arid and arid West.

Typically, the best management practices recommended for irrigating turfgrasses is to irrigate deeply and infrequently for the best turf health and conservation of water. A number of studies have emphasized this from the 1950's to today (2, 3, 5, 10, 11, 12). In semi-arid climates however, irrigation responses and recommendations may be quite different, possibly opposite. Studies done in Colorado by Fry & Butler (8) and Ervin & Koski (7) both showed the potential of saving between 10-25% in irrigation water by irrigating frequently.

Like Colorado, the Intermountain West region of the U.S. has a cool-arid climate with warm to hot summer days, cool-nights, high light intensities due to the relatively high elevation, and a generally rain-free summer growing season. These parameters cause a high evaporative demand on plants. Unlike more humid regions, increased leaf wetness caused by more frequent irrigation that may increase disease pressure is not a serious management problem due to the low humidity.

Because of the high evaporative demands, transpirational cooling is essential, but may not be adequate in some conditions to prevent heat and water stress. Frequent irrigation may supplement transpirational cooling with surface evaporation from soil and thatch, similar to syringing turf with

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PAUL G. JOHNSON, Assistant Professor, Department of Plants, Soils, and Biometeorology, Utah State University, 4820 Old Main Hill, Logan, Utah 84322-4820

USGA Turfgrass and Environmental Research Online 2(6):1-8.
TGIF Record Number: 85799

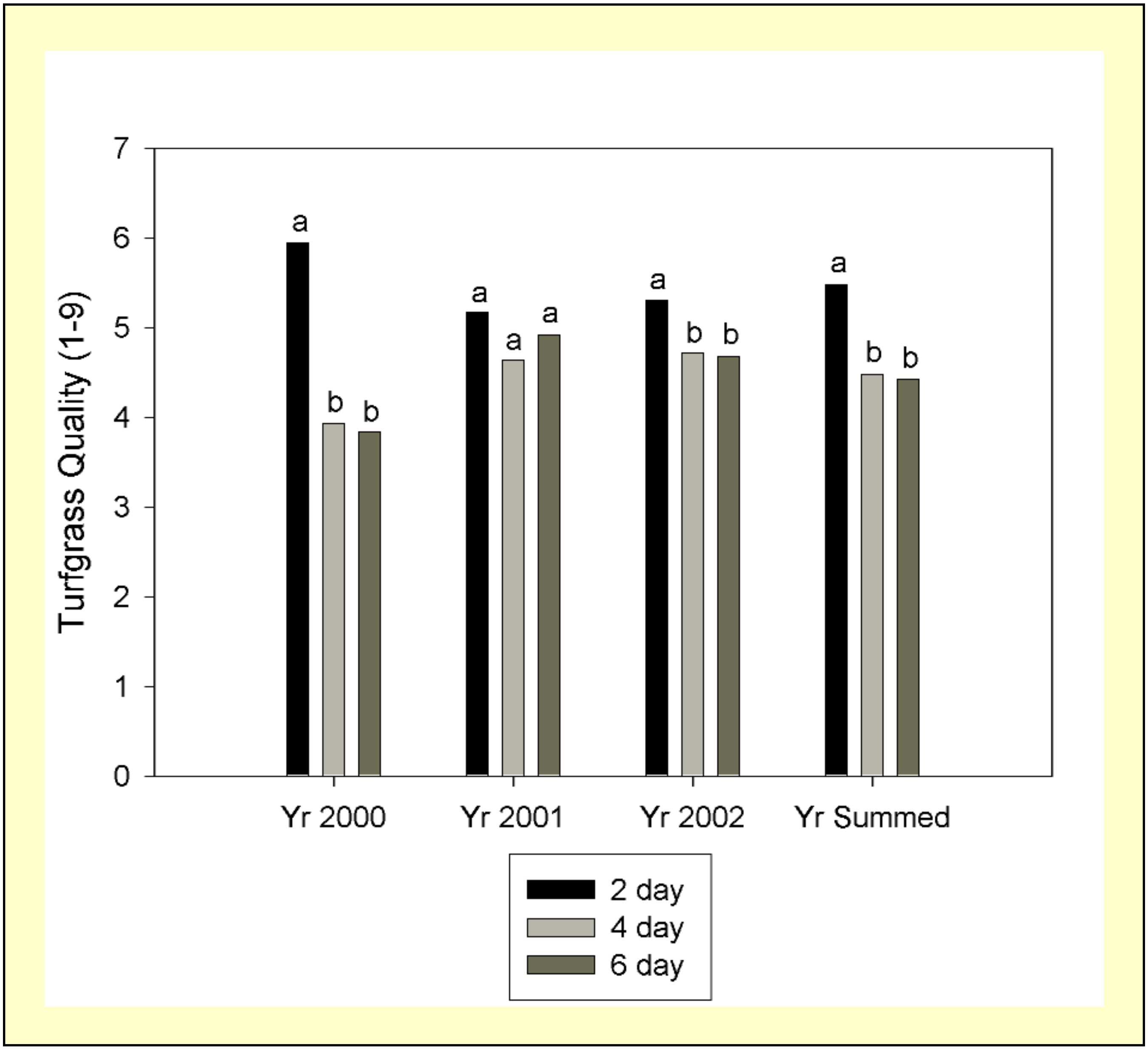

Figure 1. Turfgrass quality means for 2000 - 2002 and three-year averages of four different grasses (Kentucky bluegrass, tall fescue, prairie junegrass, and buffalograss) irrigated every 2 days, 4 days, and 6 days with 70% replaced reference ET.

short irrigation cycles. We tested this hypothesis by first observing the effects of irrigation frequency on overall turfgrass quality and measuring aspects of the turfgrass microenvironment, particularly temperature and soil moisture.

Procedure

We studied four different grasses (Kentucky bluegrass, tall fescue, prairie junegrass, and buffalograss) at three irrigation frequencies: every 2 days, 4 days, or 6 days and replaced 70% of ET_o. ET_o is frequently referred to as "reference ET", and is a calculated amount of evapotranspiration from a tall fescue turf mowed at four to six inches, using temperature, humidity, wind, and light intensity data (1). Typically, 80% of $ET_o$is recommended to maintain the quality of Kentucky bluegrass turf (11). This experiment was conducted between June of 2000 and October 2002.

At least once each month during the growing season turfgrass quality ratings were taken. Canopy temperature measurements (the tempera-

Figure 2. Plot photographs in 2000 showing differences in turfgrass quality due to irrigation interval: (A) prairie junegrass at 2-day interval; (B) prairie junegrass at 6-day interval; (C) Kentucky bluegrass at 2-day interval; and (D) Kentucky bluegrass at 6-day interval.

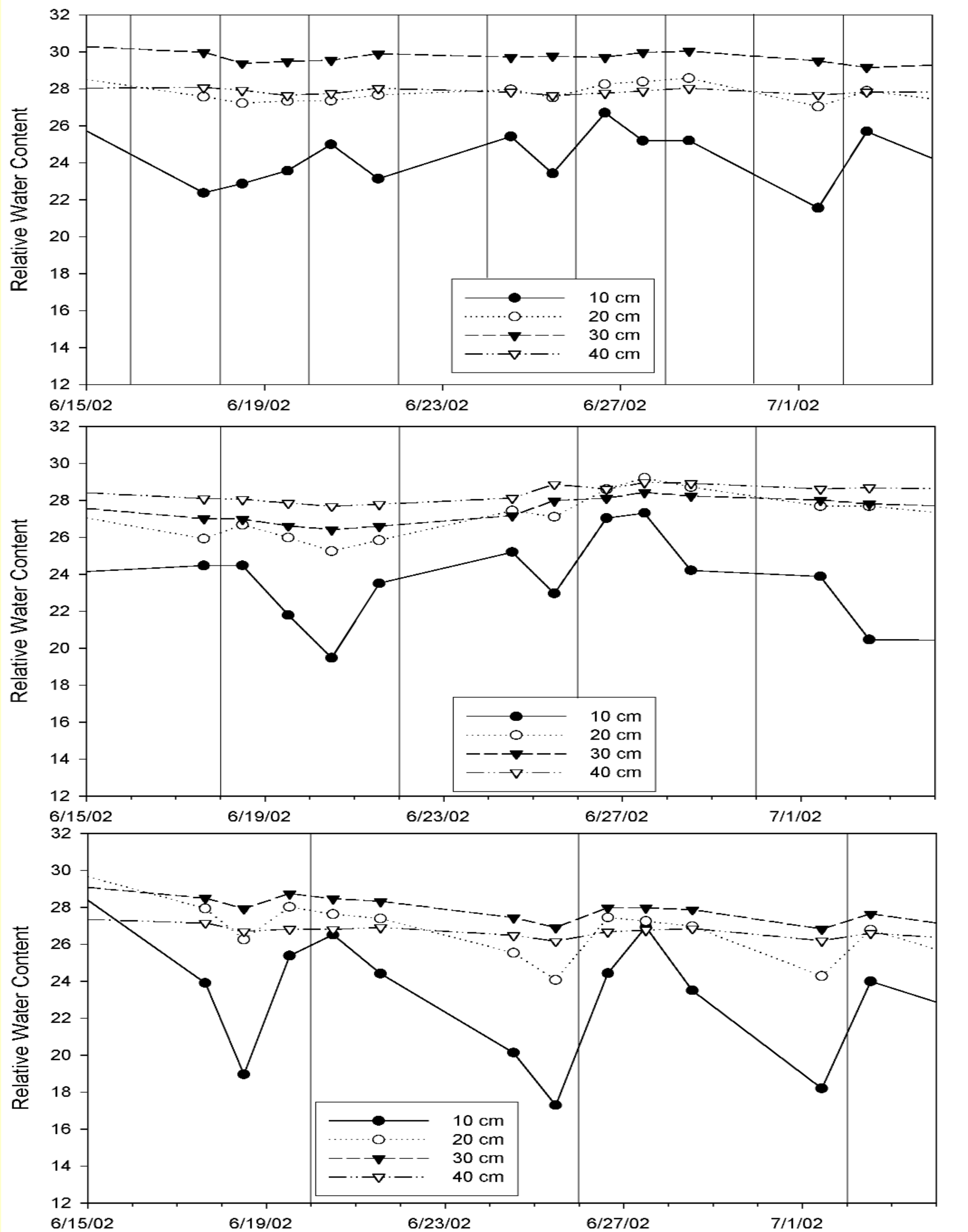

Figure 3. Soil moisture means (relative water content) at 10, 20, 30, and 40 cm depths of plots receiving irrigation on 2, 4, and 6-day intervals during a 2 1/2 week period in 2002. Vertical lines within each graph represent irrigation events.

Notes on soil moisture sensing methods

Measuring soil moisture is a rapidly evolving area of research. For many years, the use of tensiometers and gypsum blocks and similar equipment, have been described in turfgrass management textbooks. Recently, a range of newer technology has been introduced. These new instruments can be more effective than the older technology, but turfgrass managers should also be aware of their limitations.

A number of types of soil moisture probes are now being marketed to golf course superintendents. Soluble salts in the soil influence nearly all the moisture probes, including tensiometers. In addition, installation methods, soil type, and variable soil conditions also may limit their usefulness. Instruments may be more accurate in some soils and soil conditions, and others may be more accurate in other conditions. These specific soil issues may be more of a research issue than a practical use issue, however. If you invest in one or more of these sensors, relate actual moisture conditions in the soil to the readings you obtain from the instrument. In other words, "calibrate" your instrument so you can better relate a reading to soil moisture conditions.

Consistent soil-to-probe contact is also essential. For sensors that are installed permanently in sandy soils, this isn't a large problem. But in heavier textured soils, shrink-swell characteristics of the soil can cause poor results because the soil can pull away from the probe. For portable sensors that are inserted into the soil, a reading taken, and then removed, the user must be careful to insert these as carefully as possible to maximize soil contact. Don't wiggle the probes too much. The most important recommendation with any sensor is to use common sense. Are the readings making sense? If not, the probe may be malfunctioning or isn't being used properly.

The sensor used in this research is somewhat different than other methods, but still has its limitations. Rather than a moisture sensor set permanently in the soil, it consists of an access tube set permanently in the ground and a probe is inserted into the tube when taking measurements. It uses a soil capacitance type of sensor that has been very effective in soils with relatively low soluble salt levels. But because this sensor has a tube and cap extending from the turf, it's not especially useful in most turf management situations in its current configuration. Further refinement of the instrument may result in a more useful design.

Irrigation equipment manufacturers are developing improved sensors for use on golf courses. The limiting factors have traditionally been cost, reliability, and challenges of non-uniform soils. Soon more simple and reliable sensors will be available to turfgrass managers. In the meantime, if you choose to use soil moisture sensors, use them carefully, relate measurements to various soil moisture conditions, and know their limitations. If used carefully, soil moisture sensors can be very effective tools for water management.

ture of the leaf surface) were also taken at mid-day two to three times each week with a handheld infrared thermometer (Apogee Instruments, Logan, Utah). Temperature measurements of the soil and thatch were also recorded using thermocouples. Three thermocouples were placed within each plot and temperature was recorded by a datalogger each hour.

Volumetric water content of the soil was recorded four to five times each week at 10-cm intervals through the soil profile using a soil capacitance probe (Sentek Sensor Technologies). Most of the data reported in this article is from 2002, but provides the bulk of the findings from this study. A more detailed and comprehensive report of this work will be published at a later date.

Influence of Irrigation Frequency on Turfgrass Quality

Of most interest to turfgrass managers is the result of the irrigation treatments: turfgrass quality. Overall, the quality of the 2-day irrigation interval was better than the 4- and 6-day intervals. However, the differences varied from year-to-year (Fig. 1). In 2000, the 4- and 6-day intervals were stressed, while the 2-day interval plots were of high quality (Fig. 2). In 2001, we did not see any differences among the plots. In 2002, we again saw quality differences, but not to the extent of 2000. These overall trends are similar to those reported by Ervin and Koski (7) as well as Fry and

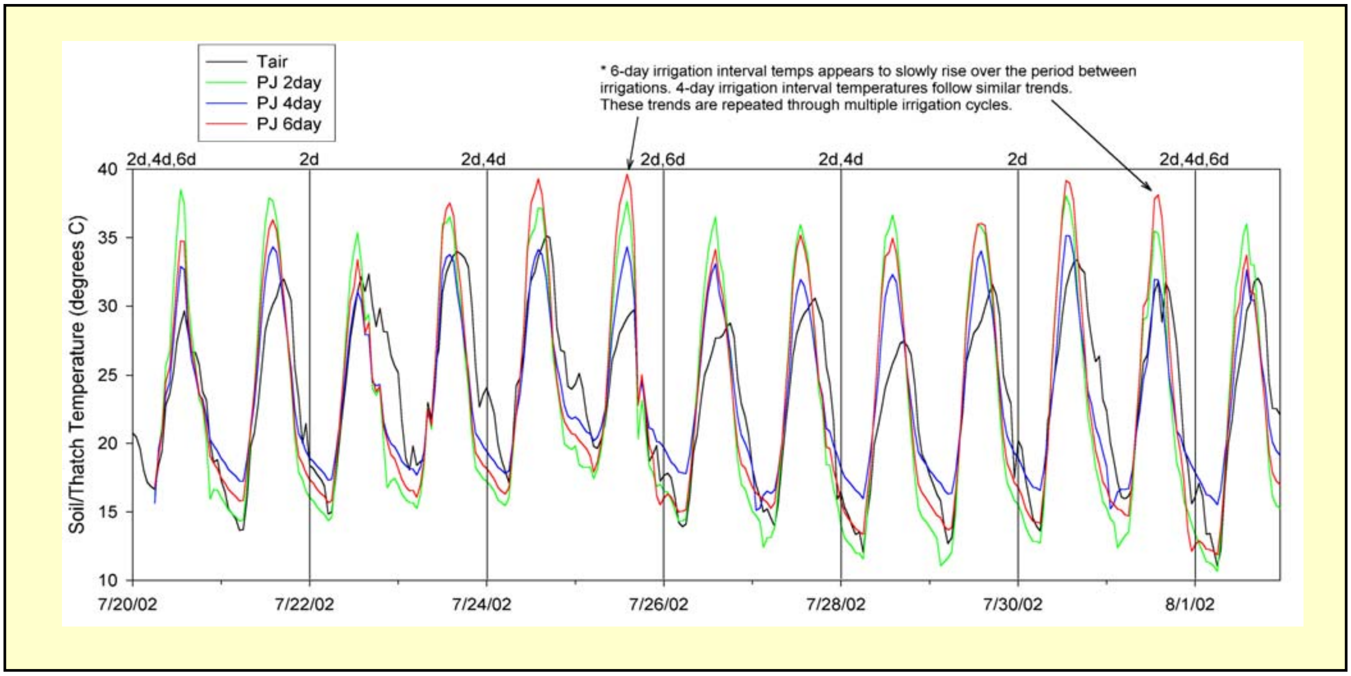

Figure 4. Soil/thatch temperatures of 2, 4, and 6-day irrigation intervals measured with thermocouples over a two-week period.

Butler (8), but opposite of the typical recommendations from much of the literature.

In addition to the visual quality of the plots, irrigation frequency also influenced the environment that the grasses were exposed to. Various aspects of the turfgrass microclimates correlate with the quality differences we observed and may be related. As expected, soil moisture changes dramatically when irrigations are spaced many days apart, as was the case with the 6-day interval treatment (Fig. 3). The 2-day interval provided a very consistent level of soil moisture over time.

Although we didn't measure root mass and root depth, we can determine the depths at which water was being absorbed, using the soil moisture data, and make the assumption that it is caused by root absorption. Prairie junegrass grown in the 4- and 6-day interval plots appear to be absorbing water at the 30-cm depth (12 inches). The 2-day interval treatment saw moisture absorbed only in the top 10 cm (4"). This data agrees with the well-known literature where consistent moisture reduces root system development (13, 12, 2, 5). Quality, however, was not reduced, but was higher in the 2-day interval treatments.

The temperature of the soil and thatch layers also was influenced by irrigation treatments. In prairie junegrass plots, the 6-day interval plots experienced increasing temperatures each day, prior to an irrigation event (Fig. 4). This trend is apparent between 7/26/02 and 8/1/02 in 2002 data. The 4-day irrigation interval plots had a similar trend of increasing temperatures, but not as distinct. Temperatures were most consistent in the 2-day interval plots. Higher moisture levels would seem to promote cooler temperatures, but in most cases, the 2-day interval plots were warmer than the other irrigation levels.

A number of researchers have looked at canopy temperature to evaluate or measure drought stress. Many times this method has proven to be useful (4, 9, 6, 14, 15). Canopy temperatures were measured periodically, but the data and trends were not consistent or meaningful across the irrigation intervals or when related to days after irrigation.

This investigation points to significant effects of irrigation frequency on turfgrass quality in the semi-arid West. At 70% ET_o replacement, which is usually considered deficient for Kentucky bluegrass, quality was maintained when moisture was replaced every other day compared to less frequent regimes. These more frequent irrigations provided a more uniform soil moisture over time and more consistent, while not usually lower, temperature for the plants.

Of course there is a downside. Quality may be higher, but frequent irrigations appear to leave the plants more vulnerable to drought stress when irrigation problems occur or irrigation is unavoidably delayed. In August of 2002, the irrigation system at the research farm was not functioning for six days. The 2-day interval plots were significantly affected and entered summer dormancy. The 4- and 6-day interval treatments appeared relatively unaffected. The reduced root development in the 2-day treatments may have contributed to this response.

Frequent irrigations alone may not be recommended because of the negative effectgs observed when irrigation is delayed. A schedule of infrequent and deep watering, possibly on a 6-day schedule combined with a light irrigation daily, or every other day, may be a good compromise between the two programs. Then, deep rooting is promoted, but the possible cooling effects, and associated water conservation of frequent irrigations can be realized.

Acknowledgements

Funding for this research was provided by the Center for Water Efficient Landscaping, the United States Golf Association, the Intermountain Golf Course Superintendents Association, the Utah Sod Producers, and the Utah Agricultural Experiment Station, Utah State University. Special thanks to Alex Stoy, Damien Stoy, and Jason Dalling for their assistance in data acquisition and equipment preparation.

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