# USING TIME DOMAIN REFLECTROMETRY FOR IRRIGATION

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The increased use of irrigation to achieve the high level of quality demanded by golfers today has created a need for evaluation of common turfgrass irrigation philosophies. This study was designed to evaluate irrigation scheduling. Penncross creeping bentgrass and annual bluegrass maintained at .5 inch were evaluated under each irrigation schedule. A nondestructive, fast and accurate method of measuring soil moisture was needed to monitor the soil moisture and determine the amount of irrigation to apply. Time Domain Reflectrometry (TDR) has been proven a useful technique to monitor soil moisture. However, it has not been used to determine amounts of irrigation water to apply. So the first objective of this study was to utilize TDR to measure how much water these turfs use under fairway type conditions as a basis for determining how much irrigation water to apply. A second objective of this study was to evaluate TDR as a tool for monitoring at what depths these turfgrasses were extracting soil moisture. A third objective was to evaluate the response of annual bluegrass and creeping bentgrass to these irrigation regimes.

## ESTABLISHMENT

During the summer of 1989 annual bluegrass seedheads were collected from plots at the Hancock Turfgrass Research Center. The seed was dried and cleaned previous to seeding. This process was labor intensive and yielded low germination percentages. Annual bluegrass is available commercially, but it was considered important that Michigan biotypes be used.

The 36' by 36' irrigation whole plots were split into two 18' by 36' split plots and seeded to annual bluegrass or creeping bentgrass. During the establishment phase annual bluegrass contamination in the bentgrass plots was significant. Light rates of Roundup were used to reduce the incidence of annual bluegrass in the bentgrass plots.

## CONSTRUCTION AND INSTRUMENTATION

The necessary equipment was acquired in the winter and spring of 1990. The TDR meter, portable computer, rotary switches, wire and probes are the main components of the system. The TDR sends a signal through the switch, into the wire and probes which were placed in the soil; the signal is reflected back to the TDR; the data from the TDR is sent to the computer where the volumetric soil moisture is calculated. The computer program for this study was written with the cooperation of Dr. Fran Pierce of the Crop and Soil Sciences Department at M.S.U. and Dr. John Baker of the University of Minnesota. Many variations of switches, probes, wires, connections and placements were tested to evaluate the best configuration for use in irrigation scheduling. The theoretical ellipse of influence of the TDR probes when placed horizontally is 5 cm in the vertical and 10 cm in the horizontal. Because of this the probes were placed to measure the 0-5 cm, 5-10 cm, 10-15 cm and 15-25 cm zones. The first three zones were replicated 3 times in each species and the lowest zone twice as each switch had 11 positions. Each split plot had 11 probe pairs and each whole plot had 22 pairs, for a total of 198 probe pairs. The design of the equipment allowed for daily volumetric soil moisture measurements. Over 20,000 TDR volumetric soil moisture readings were taken during the 1991 season.

Several sprinkler heads were tested for uniformity of distribution for the rectangular design of these plots. After finding an acceptable head, 100 collection cans were placed on 4 foot centers over the whole plot. This routine was repeated 3 times for each plot for a total of 2700 measurements. It was found that in our design .1 inch of water could be applied in 6 minutes of irrigation run time. Distribution uniformity over the whole plots averaged 64.3%. In the center of the plot where the probes are located the average uniformity of distribution is 83.1%. These calculations were made using the turfgrass irrigation system evaluation program written by Dr. Richard Snyder of the University of California, Davis. This program will be of benefit to the turfgrass industry in evaluating irrigation systems under field conditions.

## EXPERIMENTAL DESIGN

The study was a three replication split-split plot design. The whole plot treatments were: 1) irrigation to bring the soil moisture to field capacity on a daily basis; 2) .1 inch irrigation daily; and 3) irrigation when footprinting symptoms appeared on the turf. The first split was grass species, bentgrass and annual bluegrass. The second splits were the depth measurements of soil moisture utilizing the TDR. This design allows us to look at the effects of irrigation treatments alone, the effects of irrigation regime on each species, and the effects of irrigation and/or species on the soil moisture content at each depth and over the entire 25 cm profile.

## CORRELATION

One objective of the study was to evaluate TDR as a method of volumetric soil moisture measurement. Soil bulk density was determined for use in calculating volumetric soil moisture from soil samples removed for comparison to the TDR reading. Sampling began in 1990 and continued through fall of 1991. Table 1 has the coefficient of correlation data for all depths. These data represent comparisons for over 1500 gravimetric determinations with the TDR moisture measurements. Although there is a strong correlation between the two methods we believe future data will be more accurate. New connection techniques and electronic switching devices are available that will improve accuracy.

Table 1.
Coefficients of Correlation, TDR and Soil Sample Methods

| Depth | 0-5 cm | 5-10 cm | 10-15 cm | 15-25 cm | 0-25 cm |
|---|---|---|---|---|---|
| Coefficient of Correlation | .90 | .90 | .88 | .83 | .85 |

## QUALITY RATINGS

Weekly quality ratings were taken during the 1991 season. Because of the factorial design of the experiment the significance of interactions determines the analysis. When significant interactions occurred, the effects of irrigation on the quality ratings for each species are presented. When interactions are not significant the difference between species over all irrigation treatments, and the differences between irrigation treatments over both species are presented.

Table 2 shows that Penncross creeping bentgrass performed better than annual bluegrass when averaged over all irrigation treatments. The differences were particularly evident when irrigated upon the appearance of wilt stress. In Table 3, it is apparent that there was no significant difference between plots irrigated at field capacity or when irrigated with .1 inch daily when averaged for both grasses. But the plots irrigated at stress had lower quality than under the other two irrigation regimes.

Table 2. Turfgrass Quality Ratings of turfgrass species averaged over all irrigation treatments. Quality ratings: 9=Excellent, 1=Poor

| Date | 6/16 | 7/8 | 9/5 |
|---|---|---|---|
| Bentgrass | 6.7 | 7.3 | 7.8 |
| Annual Bluegrass | 4.8 | 5.9 | 7.6 |
| LSD .05 | 0.4 | 0.6 | NS |

Table 3. Turfgrass Quality Ratings among irrigation treatments averaged over both turfgrass species. Quality ratings: 9=Excellent, 1=Poor

| Date | 6/16 | 7/8 | 9/5 |
|---|---|---|---|
| Field Capacity | 6.3 | 7.1 | 8.0 |
| .1 Inch Daily | 6.0 | 6.8 | 7.9 |
| Stress | 4.8 | 6.0 | 7.2 |
| LSD .05 | 0.6 | 0.9 | 0.5 |

## WEIGHTS

Clippings were collected weekly. No significant differences were found among species or irrigation treatments. This is not consistent with the quality rating data and may be a result of the low degree of statistical power of the design.

## ROOT DATA

Root samples were taken on July 17 and September 4, 1991. Samples were taken from each of the soil moisture measurement (depth) zones. Thatch samples were collected on September 4, 1991. Bentgrass produced more roots than annual bluegrass in the 0-5 cm and 15-25 cm depths on July 17 when averaged over all irrigation treatments. On September 4 bentgrass produced more roots than annual bluegrass in the 0-5 cm, 5-10 cm and 10-15 cm zones. No differences were found in thatch accumulation. On the July 17 and September 4, 1991 sampling dates no differences were found in root production of either species when averaged over irrigation treatments.

## SPECIES COMPETITION

Density counts of the two grasses in each plot were measured to evaluate the amount of encroachment of one species into the other within each irrigation treatment (Tables 4, 5 and 6). Bentgrass encroached into all plots with the exception of the .1 inch daily irrigation bentgrass plot where annual bluegrass increased 4.3% over the 1991 season. Under the stress irrigation treatment the annual bluegrass plots had an increase in bentgrass of 27% over the 1991 season. The percentage of bentgrass in the bentgrass plots was over 90% in all irrigation treatments. By August 23, 1991 the annual bluegrass percentages had dropped to 53.6% in the .1 inch daily treatment, 60.7% in the field capacity treatment and 39.7% in the stress treatment.

## MOISTURE MONITORING AND IRRIGATION SCHEDULING

Soil moisture measurements were taken daily and used to evaluate soil moisture by zone and to schedule irrigation. The benefit of volumetric moisture content data is that is can be easily converted to minutes of irrigation needed to return the soil to any chosen moisture level. Field capacity was determined to be 28.1%. On the field capacity plots, soil moisture was returned to that moisture level each day. The field capacity, .1 inch daily and stress treatment soil moisture contents were monitored for statistical evaluation.

The field capacity treated plots had very little fluctuation in volumetric soil moisture content as might be expected. The .1 inch daily treatment did not provide enough water resulting in moisture stress during periods of no precipitation. When adequate rainfall events occurred the soil moisture returned to field capacity. The plots irrigated on stress received irrigation only three times during the season. Field capacity plots received 668 minutes or 11.1 inches of water, the .1 inch daily received 462 or 7.7 inches of water and the stress plots 183 or 3 inches of irrigation.

Soil moisture was monitored for the entire 25 cm zone and for each depth and species. Since there is a great volume of data in this category it will not be presented here. The data do reveal a trend for higher moisture contents in the annual bluegrass plots regardless of irrigation treatment, especially at the 15-25 cm depths.

## CONCLUSIONS

The high degrees of correlation and the success of the TDR system for monitoring and scheduling irrigation provides a valuable research tool for evaluating turfgrass responses under set or variable moisture contents. The ability to evaluate water use by grass at given depths is important in formulating an irrigation strategy. Converting soil moisture use to minutes of irrigation will allow the researcher to provide useful irrigation scheduling information to the turf manager. The comparison of annual bluegrass and creeping bentgrass, quality, rooting, clipping, encroachment and soil moisture characteristics under different irrigation regimes will provide valuable knowledge for maintenance of each species. Studies with TDR will be continued.

Table 4. .1 INCH DAILY IRRIGATION
CHANGE IN SPECIES COMPOSITION, 1991
AVERAGES OF THREE REPLICATIONS

| | POA SPLIT | | BENT SPLIT | |
|---|---|---|---|---|
| | % POA | % BENT | % POA | % BENT |
| May 29 | 77.1 | 22.9 | 4.2 | 95.8 |
| August 23 | 53.6 | 46.4 | 8.5 | 91.5 |
| % Change | -23.5 | 23.5 | 4.3 | -4.3 |

Table 5. FIELD CAPACITY MAINTAINED
CHANGE IN SPECIES COMPOSITION, 1991
AVERAGES OF THREE REPLICATIONS

| | POA SPLIT | | BENT SPLIT | |
|---|---|---|---|---|
| | % POA | % BENT | % POA | % BENT |
| May 29 | 71.9 | 28.1 | 12.5 | 87.5 |
| August 23 | 60.7 | 39.3 | 6.2 | 93.8 |
| % Change | -11.2 | 11.2 | -6.3 | 6.3 |

Table 6. STRESS TREATMENT
CHANGE IN SPECIES COMPOSITION, 1991
AVERAGES OF THREE REPLICATIONS

| | POA SPLIT | | BENT SPLIT | |
|---|---|---|---|---|
| | % POA | % BENT | % POA | % BENT |
| May 29 | 66.7 | 33.3 | 9.4 | 90.6 |
| August 23 | 39.7 | 60.3 | 3.9 | 96.1 |
| % Change | -27.0 | 27.0 | -5.5 | 5.5 |