EFFICIENT IRRIGATION FOR RECREATIONAL TURF: EVAPOTRANSPIRATION AND CROP COEFFICIENTS

Proposal submitted to the NERTF for Research Funding

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EXECUTIVE SUMMARY

Advocacy groups as well as state and federal governments consider the application of water to lawn and recreational turf as wasteful of a precious natural resource. Restrictions by EPA have been drafted requiring ET-based irrigation. Scheduling irrigation according to actual turfgrass evapotranspiration rates (ET_a) reduces waste and increases irrigation efficiency. To that end, research based crop coefficients (K_c) for recreational turf (golf and sports) is needed to implement efficient irrigation practices as proposed by the EPA. We propose to develop monthly K_c values derived from weather station predicted ET (ET_0) and actual turfgrass ET (ET_a) measured using weighing lysimeters to assist turf practitioners in implementing ET-based irrigation. We are requesting \$10,000 per year for three years (2009-11) to fund (part-time) assistance to help the principal investigators in collecting field data.

INTRODUCTION

Lawn and recreational turf can require significant amounts of irrigation to maintain turf function and use. Practices that lower water requirements are especially important as water restrictions and demand for water increase. Restrictions of consumptive water use in turfgrass systems including lawn landscapes and recreational turf are under scrutiny by state and federal governments as well as advocacy groups as a principal means of reducing water usage. On May 22, 2008, the EPA drafted specifications for implementing landscape designs to (i) restrict the use of turf to no more than 40% of the total landscape area and (ii) irrigation to no more than 60% of reference evapotranspiration (ET_0) (www.epa.gov/watersense/specs/homes.htm). The EPA water budget calculation will be implemented nationwide, regardless of the significant variability in climatic conditions and water usage by different turfgrass species. Since most cool-season grasses require greater irrigation than allowed by current EPA water budget estimates, this could have a significant impact on the use of cool-season turfgrasses in new landscapes. Moreover, the EPA has not provided any scientific-based justification for their water budget calculation. As a result, it is crucial for the turfgrass industry to provide actual scientific data on irrigation strategies that conserve water while still maintaining turf function and quality.

Scheduling irrigation according to actual turfgrass water use rates (ET_a) reduces waste by replacing only the amount of water lost from the rootzone to turfgrass use. Numerous studies have been conducted to measure ET_a of species (Youngner et al., 1981; Aronson et al., 1987; Kim and Beard, 1988; Fry and Butler, 1989) and within cultivars of the same species (Kopec et al., 1988; Shearman, 1989; Ebdon and Petrovic, 1998). Weighing lysimeters are the most accurate method for estimating ET_a, however, lysimetry is labor intensive and this method is not very practical for scheduling irrigation events in the field. Therefore, mathematical models such as the FAO modified Penman equation (Doorenbos and Pruitt, 1984) have been developed that use climatic data from weather stations as a standard reference ET value (ET_0). Reference ET values derived from weather data deviate from ET_a, therefore, ET_0 values must be adjusted using crop coefficients (K_c values) to achieve a more accurate estimate of ET_a. Crop coefficients are derived from the ratio of ET_a-to-ET_0 and are determined experimentally.

Higher clipping dry weight (growth rate), shoot density and leaf area have been associated with greater turfgrass ET (Beard, 1989). Growth characteristics and ET_a have been shown to be affected significantly by genetic variation due to species (Kim and Beard, 1988), cultivar (Ebdon and Petrovic, 1998) and due to variation in maintenance practices with ET_a increasing with nitrogen (Ebdon et al., 1999) and height of cut (Biran et al., 1981). As such, K_c values can vary with the season, cultural intensity (height of cut, nitrogen fertilization) and species.

An important strategy for reducing irrigation requirements is the need to develop a system to schedule irrigation such as the California CIMIS (CIMIS; Snyder, 1986) and Arizona AZ-MET (AZ-MET; Brown, 1998). These systems are based on a daily estimate of potential ET (i.e., ET_0) usually developed from climatic data, which are then adjusted with an appropriate K_c value that provides a better estimate of actual turfgrass ET (Kneebone et al., 1992). Semi-arid regions including Arizona and Colorado have developed and tested the use of crop coefficients to schedule irrigation (Brown, 1998; Kneebone et al., 1992; Ervin and Koski, 1998).

Aronson et al. (1987) found that daily reference ET_0 values derived from meteorological data using the modified Penman equation were more reliable than pan evaporation data and could be used as a reliable method for scheduling irrigation in southern New England. In the same study, K_c values were calculated for three different cool season turfgrass species including Kentucky bluegrass (*Poa pratensis* L.), perennial ryegrass (*Lolium perenne* L.) and fine fescue (*Festuca* species) maintained under the same level of culture (2-inch height of cut). They also reported that a K_c value of 1.0 would be appropriate for irrigating turf in southern New England. Alternatively, in Colorado, acceptable turf quality was maintained by irrigating Kentucky bluegrass turf according to Penman predicted ET_0 adjusted using a K_c value of 0.7 (Ervin and Koski, 1998).

There is a lack of ET data and K_c values specific for climatic conditions typical of northern New England and cultural intensity (species, height of cut, nitrogen fertilization programming) more representative of recreational areas used for sports and golf turf. The Aronson study was conducted in the southern New England coastal region of Kingston RI (latitude and longitude 41.30°N and 71.30°W, respectively) and emphasized lawn turf species and culture atypical of sports and golf conditions. Crop coefficients are fractional percentages of a base (reference) value that must be determined on a local basis to determine actual water requirements (i.e., using minilysimeters). Locally developed research-based K_c values are important to improving water conservation because K_c values can be expected to vary with different species and cultural management factors. As such, additionally research is needed to develop turfgrass database for ET and crop coefficients under cool-humid conditions of New England that are relevant to recreational turf and climatic conditions located further inland from coastal, southern New England regions.

OBJECTIVES

The objective of this study is to compare the water use and crop coefficients of three turf species maintained under diverse culture representing low and high maintenance conditions typical of recreational turf. Crop coefficients will be computed using the FAO modified Penman equation (Doorenbos and Pruitt, 1984) for golf species [creeping bentgrass (*Agrostis stolonifera* L.)] maintained as green and fairway turf and sports grass species (Kentucky bluegrass and perennial ryegrass).

MATERIALS AND METHODS

Test Areas and Turf Water Use (ET_a)

Studies will be conducted in the field at the Joseph Troll Turf Research Facility, South Deerfield, MA. Evapotranspiration rates of individual plots are to be measured using the gravimetric mass balance method with minilysimeters to represent actual turfgrass ET (ET_a). Minilysimeters allow for direct calculation of mass changes due to plant water uptake and soil evaporation and have been utilized in several investigations on turfgrass ET (Feldhake et al., 1983; Aronson et al., 1987; Qian and Fry, 1996). Measurement of ET_a based on weighing lysimeters is distinguished from ET_0, where ET is estimated instead by means of an empirical model and based on climatic data (Kneebone et al., 1992). Approximately one month prior to the initiation of ET measurements, cores including intact plants and soils (10 cm diameter and 20 cm deep to include a majority of the root system) will be removed from established field plots using a cup cutter and placed into polyvinyl chloride (PVC) tubes of the same size as the cores to form minilysimeters. Nylon mesh screen will be taped to the bottom of each PVC tube in order to maintain the plant and soil column intact while allowing for water drainage out of the minilysimeters. Minilysimeters will receive the same environmental and management conditions as the rest of the surrounding plot area. Minilysimeters will be pulled out of the plots daily and weighed at 24 hour intervals with a balance providing accuracy to the nearest gram. Daily ET_a will be calculated based on the difference in the weight of minilysimeters at 24-hour intervals.

Existing stands of ‘Bright Star SLT’ perennial ryegrass and a three way blend (‘Midnight’, ‘P-105’, and ‘Odyssey’) Kentucky bluegrass will be used as sources of plant material for establishing ‘sports turf’ treatment plots. Kentucky bluegrass and perennial ryegrass are principal species used in athletic fields in cool-season climates (Puhalla et al., 1999). Perennial ryegrass and Kentucky bluegrass plot areas will be maintained under two levels of culture, 1) high maintenance: 1.25 inch height of cut and fertilized four times per year at 1.0 pound of N per 1000ft^2 per application (4.0 pounds total N per 1000ft^2 per season) and 2) low maintenance: 3 inch height of cut and fertilized two times per year at 1.0 pound of N per 1000ft^2 per application (2.0 pounds total N per 1000ft^2 per season). In addition, preexisting golf turf areas planted to ‘Memorial’ creeping bentgrass will be used as sources of plant material for establishing ‘golf turf’ treatment plots and will be maintained under two levels of culture, 1) green (high maintenance): 0.125 inch height of cut and fertilized with 4.0 pounds total N per 1000ft^2 per season and 2) fairway (low maintenance): 0.5 inch height of cut and fertilized at 2.0 pounds total N per 1000ft^2 per season. Six treatments consisting of three species by two cultural management levels will be used in this study.

Reference Evapotranspiration (ET_0) and Crop Coefficients (K_c)

Doorenbos and Pruitt (1984) defined a reference crop evapotranspiration (ET_0) as the rate of evapotranspiration from a uniform grassy surface growing under non-limiting soil moisture and maintained at approximately 3 to 6 inch height of cut. Reference crop evapotranspiration (ET_0) can be measure by two methods including the US weather service Class A pan or by using aerodynamic equations such as the FOA Penman equation (Doorenbos and Pruitt, 1984). According to Aronson et al. (1987), the Penman mathematical model predicted ET (ET_0) derived from weather data has been shown to be more reliable than pan ET_0 in the cool-humid New England region. Therefore, in this proposed study, predicted ET_0 using the FOA Penman equation derived from climatic data will be used. For a detailed description of the FOA Penman equation to be used in this proposed study see Doorenbos and Pruitt (1984).

Crop coefficients (K_c) for the Penman equation and predicted ET_0 will be determined daily according to weather data and compared to actual ET_a from weighing lysimeters, thereby K_c values will be calculated as ET_a/ ET_0. The weather station to be used to collect climatic data (net radiation, air temperature, relative humidity, and wind speed) is located within 600 ft of all tests areas and completely surrounded by a mowed grassy surface maintained at less than 3.0 inch height of cut in all directions. Daily reference ET will be calculated by summing hourly predicted ET_0 for each 24-hour period. Daily ET_a will be determined in the field using minilysimeters during periods when no input into the system from irrigation and rainfall occurs and all output from the system due to drainage and runoff is zero. Accordingly, daily ET_a and reference ET_0 will be determined during each 24-hour period providing no rainfall is observed over the 24-hour measurement period. Evapotranspiration (ET_a and ET_0) and crop coefficients will be calculated beginning in late June and will be terminated by late September. The study will be begin in 2009 and repeated in 2010 and 2011.

Two minilysimeters will be installed in each of the six treatment plots (5 by 10 ft) consisting of a 3 by 2 factorial arrangement of three species (creeping bentgrass, Kentucky bluegrass and perennial ryegrass) by two maintenance schedules (low and high cultural intensity). Four replicates arranged as a randomized complete block design will be used. Mean daily ET_a and ET_0 as well as data means for crop coefficients will be computed on a bi-weekly basis and the combined means for comparing between maintenance schedules (low and high cultural intensity) and species (creeping bentgrass, Kentucky bluegrass and perennial ryegrass) will be tested at the *t*-probability level of 0.05.

EXPECTED RESULTS

Water conservation in turfgrass will require data such as crop coefficients for assisting turf practitioners in applying ET-based irrigation to turfgrass. To that end, summing of ET_0 for a period since the last irrigation corrected for rainfall, then multiplied by the appropriate K_c for that period (month) to compute ET_a requires research-based data. A variety of factors influence K_c values such as the level of turfgrass quality required, the stage of development (growing season) and the intensity of management (height of cut and N). We believe that this research will provide meaningful data that is urgently needed by professional turf managers to efficiently schedule irrigation to lawn and recreational turf.

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KC-ET STUDY PLOT PLAN

BLOCK 1	6 High HOC Low HOC CBG 4 lbs N	2 Low HOC High HOC KBG 2 lbs N	1 High HOC Low HOC KBG 4 lbs N	3 Low HOC High HOC PRG 4 lbs N	4 High HOC Low HOC PRG 2 lbs N	5 Low HOC High HOC CBG 4 lbs N
BLOCK 2	1 High HOC Low HOC KBG 4 lbs N	5 High HOC Low HOC CBG 4 lbs N	3 Low HOC High HOC PRG 4 lbs N	2 Low HOC High HOC KBG 2 lbs N	6 High HOC Low HOC CBG 4 lbs N	4 High HOC Low HOC PRG 2 lbs N
BLOCK 3	4 Low HOC High HOC PRG 2 lbs N	3 High HOC Low HOC PRG 4 lbs N	6 Low HOC High HOC CBG 4 lbs N	2 Low HOC High HOC KBG 2 lbs N	5 High HOC Low HOC CBG 4 lbs N	1 Low HOC High HOC KBG 4 lbs N
BLOCK 4	6 High HOC Low HOC CBG 4 lbs N	4 High HOC Low HOC PRG 2 lbs N	2 High HOC Low HOC KBG 2 lbs N	1 High HOC Low HOC KBG 4 lbs N	5 Low HOC High HOC CBG 4 lbs N	3 High HOC Low HOC PRG 4 lbs N

5ft

10ft

KC-ET TREATMENTS

1. 'Touchdown' Kentucky bluegrass 4 lbs N/1000ft^2/yr
2. 'Touchdown' Kentucky bluegrass 2 lbs N/1000ft^2/yr
3. 'Exacta' perennial ryegrass 4 lbs N/1000ft^2/yr
4. 'Exacta' perennial ryegrass 2 lbs N/1000ft^2/yr
5. 'Memorial' creeping bentgrass 4 lbs N/1000ft^2/yr
6. 'Memorial' creeping bentgrass 2 lbs N/1000ft^2/yr

All main plots are split according to HOC

KBG & PRG: Low HOC (1.25 in.) & High HOC (2.5 in.)

CBG: Low HOC (1/8 in.) & High HOC (3/8 in.)