Efficient Irrigation of Golf Turf in the Cool–Humid New England Region

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Objectives:

Develop research based crop coefficients (K_c) for efficient irrigation practices in recreational turf (golf and sports) under maintenance and climatic conditions typical of the New England region.

Scheduling irrigation according to actual turfgrass evapotranspiration rates (ET_a) reduces waste and increases irrigation efficiency. Landscape and crop coefficients (K_c values) are used in association with weather station reference ET (ET_0) to accurately predict ET_a. Experimentally derived K_c values need to be developed at the local level to ensure optimum turf function and effective irrigation efficiency specific to the region. Specifications (i.e., WaterSense®) developed by the US EPA have been drafted to restrict irrigation to only 60 to 80% of ET_0. These EPA WaterSense guidelines may severely impact turf function in the cool–humid New England region because EPA K_c recommendations are based on California data.

In this study we compared ET_a measured using weighing lysimeters with reference ET_0 for one golf turf species (creeping bentgrass, CBG) maintained as green and fairway, and two sports grass species (Kentucky bluegrass, KBG and perennial ryegrass, PRG). The reference ET_0 was measured using the standard reference value computed using the United Nations Food and Agricultural Organization report 56 (FAO 56 equation). Studies were initiated in 2011 at the Joseph Troll Turf Research Facility, South Deerfield, MA. Pure stands measuring 1.5 by 3 m of "Exacta" PRG and "Touchdown" KBG were established to represent sports grass while 'Memorial' CBG was used as green and fairway turf. Sports grass height of cut (HOC) was maintained at 3.2 and 6.4 cm, while CBG plots were maintained at 0.32 and 0.64 cm HOC. All treatment plots received either 98 or 196 kg N ha^{-1} yr^{-1}. During the irrigation season the 98 kg N ha^{-1} yr^{-1} rate received no fertilizer while the 196 kg N ha^{-1} yr^{-1} treatment received 49 kg N ha^{-1}. Fertilizer was applied during the irrigation season during the first week of July.

Figure 1. Installation of mini–lysimeters into tall grass perennial ryegrass plots.

Two methods were used to calculate K_c values. Method 1 calculated K_c values as the ET_a–to–ET_0 ratio based on yearly (seasonal) averages derived from daily ET measurements. Alternatively with Method 2, K_c values were calculated using linear regression analysis with ET_a as the dependent and ET_0 as the independent variable. In Method 2, the regression intercept was forced through zero and the regression slope was used to estimate the K_c value as an alternative to the ET_a–to–ET_0 ratio method. In 2011, 24 daily ET_a (using weighing lysimeters) and ET_0 (using FAO 56 equation)

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measurements were used to derive K_c values during the summer months beginning late June and ending late August. In 2012, 30 daily ET measurements were made to calculate K_c values over the same period. Reference ET values derived using the FAO 56 equation were correlated with ET_a in 2011 ($r=0.78$, $P\leq0.001$) and in 2012 ($r=0.92$, $P\leq0.001$); therefore ET_0 was effective in predicting actual turf ET.

Since K_c values are calculated directly from ET_a measurements, conditions or practices that increase or decrease turf ET (ET_a) also increase or decrease K_c values. Accordingly, a 10% increase in ET_a will increase

Figure 2. Taller grass plots used more water as ET and in turn exhibited higher K_c values. The different heights of cut for perennial ryegrass were 3.2 (1.25 inches) and 6.4 cm (2.5 inches).

Figure 3. Differential height of cut with creeping bentgrass in the immediate foreground and tall perennial ryegrass and Kentucky bluegrass plots in the

Table 1. Results for crop coefficient (K_c) values in 2011 and 2012 calculated using regression analysis (slope estimate) and as ET_a–to–ET_0 ratio derived from daily ET measurements from late June to late August. Twenty four daily ET measurements were made in 2011 and 30

Factor	Kc slope ± 95% CI†		Kc ET_a–to–ET_0		Leaf growth, mm d^{-1}	
Species	2011	2012	2011	2012	2011	2012
KBG	1.29±0.08	1.29±0.04	1.28a‡	1.28a	2.5a	2.1a
PRG	1.14±0.08	1.19±0.05	1.13b	1.16b	2.4a	2.0a
CBG	0.99±0.10	0.95±0.08	0.98c	0.96c	1.3b	0.9b
N, lbs $1000ft^{-2}$						
0	1.11±0.07	1.13±0.05	1.11a	1.10a	1.8b	1.5b
1	1.17±0.09	1.16±0.04	1.15a	1.16a	2.3a	1.8a
HOC						
Low	1.12±0.08	1.08±0.05	1.11a	1.07b	2.2a	1.6b
High	1.16±0.08	1.21±0.04	1.15a	1.19a	1.9a	1.8a
Year Average	1.15±0.09	1.14±0.05	1.13	1.13	2.0	1.7

†95% confidence interval derived from regression analysis. For comparison within the same factor.
‡Numbers followed by the same letter within the same factor are not statistically different at the 0.05 level.

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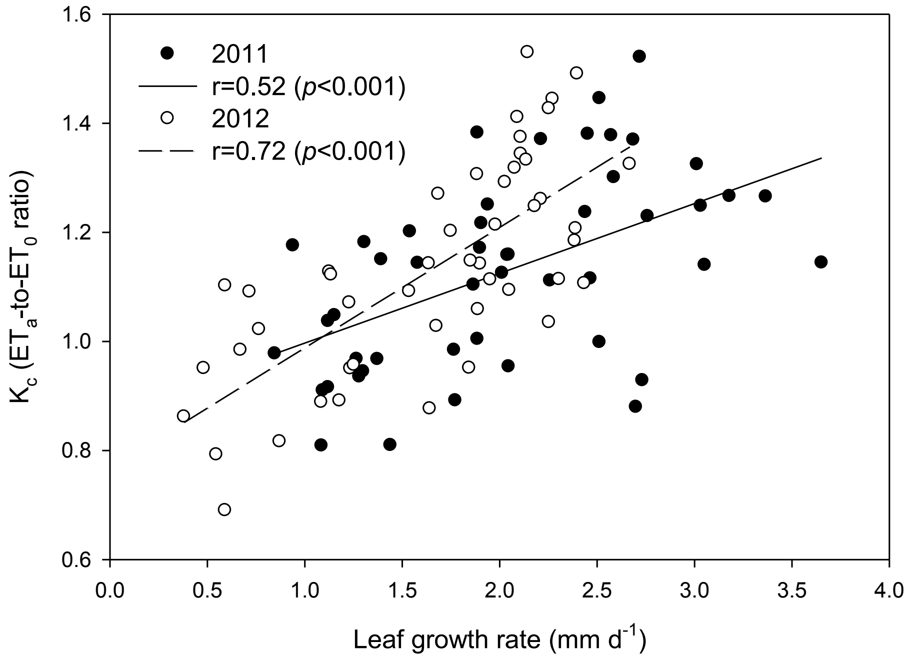
K_c values by 10%. In 2011, HOC had no effect on K_c values regardless of the method used (slope or simple ratio) to estimate K_c values (Table 1). In 2012, however, the lower HOC resulted in 10 to 15% lower K_c values (and lower ET_a) according to both methods to estimate K_c. In both years, N fertilization rate had no significant effect on K_c values. The N source used in summer was derived from methylene urea with 82% of the total N as slow–release nitrogen (SRN). As such, fertilization in summer with 49 kg N ha^{-1} was no different in K_c and ET_a from unfertilized plots. The N source used had no statistical effect on ET_a even though leaf growth rates were greater for fertilized plots in both years (Table 1). The K_c values calculated were similar for both years of study and for both methods used to estimate K_c (Table 1).

Figure 4. Relationship between leaf growth rate and K_c values derived from Et_a and ET_0 measurements.



Taller grass species, especially KBG, exhibited 25% higher ET_a and K_c values than short grass CBG fairway and green HOC (Table 1). Kentucky bluegrass K_c in 2011 and 2012 averaged approximately 1.28, followed by PRG with an average K_c value of 1.16, and CBG with the lowest average K_c value of 0.97. In both years and according to the two methods used to estimate K_c values, KBG was statistically greater than PRG, and PRG was greater than CBG. Furthermore, KBG and PRG exhibited greater leaf extension rates than CBG in 2011 and 2012 (Table 1). There was a strong correlation in 2011 and 2012 between leaf growth rates and K_c values, with K_c increasing with daily leaf extension rate (Figure 4). As such, practices that help to reduce vertical leaf extension rates will minimize K_c values by reducing turf ET.

After two years of field study, results indicate that a lower K_c value may be more appropriate for golf fairway and green turf compared to taller grass. Short cut golf turf offers potential water savings and in turn K_c values that are 15 to 25% lower compared to sports turf. In this study, the shorter HOC along with CBG slower leaf extension rates contributed to this species lower ET_a and K_c. Implementation of WaterSense® specifications of 60 to 80% of reference ET_0 when using FAO 56 as the reference ET_0 value may severely under estimate actual cool–season turf water use in summer for the cool–humid New England region.

Summary Points

- K_c values, calculated as the ratio of ET_a–to–ET_0 from daily ET measurements or using regression analysis, were significantly lower in both years of study for golf turf compared to taller sports grass. CBG exhibited 15% lower K_c values than PRG, and 25% lower K_c values than KBG turf.
- K_c values increased with leaf extension rates with KBG and PRG exhibiting higher leaf growth rates than CBG.
- K_c values and the two methods used to estimate K_c were similar during the 2011 and 2012 irrigation season from late June to late August.
- Effects of differential HOC on ET_a and K_c values were statistically significant in some years but the effects were small (4 to 5%) between the low and high HOC. Plots fertilized in summer with SRN helped to minimize ET_a and K_c values, which were no different from unfertilized plots.
- US EPA WaterSense® proposed K_c values of 60 to 80% of reference ET_0 may severely under estimate irrigation requirements when using the FAO 56 equation to calculate reference ET_0 for cool–season turfgrass species in the cool–humid New England region.

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