Turfgrass ET from Small Weighing Lysimeters in Colorado: Two Season Results under Adequate Moisture Conditions

Mark A. Crookston, P.E., CAIS, CLIA

Northern Water, 220 Water Avenue, Berthoud, Colorado, USA 80513

Mary J. Hattendorf, PhD

Northern Water, 220 Water Avenue, Berthoud, Colorado, USA 80513

Abstract. *The purpose of the study was to quantify evapotranspiration of several varieties of turfgrass, under adequate moisture conditions and with adequate fertility, for use with SMART irrigation controllers. Small weighing lysimeters were planted to 10 different turfgrass species or mixes in 2010, including 9 cool season grasses and 1 warm season mix, with four replicates of each turfgrass. Measured daily ET was compared to ETos calculated using data from an adjacent weather station and the standardized Penman-Monteith equation. The results from 2011 and 2012 are presented.*

Each lysimeter is centered in a 4-ft by 4-ft plot of the same grass variety. All grasses are mowed to the same height of 3 inches. The lysimeters each consist of a PVC shell containing a 12-inch diameter, free-draining sandy loam soil core having a 20-inch rooting depth. The lysimeters are continuously weighed in-place by electronic load platforms connected to a data logger. Irrigation is applied via high uniformity sprinklers and measured through a flow meter monitored by a data logger. All turfgrasses are irrigated on the same schedule and are managed to avoid soil moisture induced stress – all received the same base watering. As needed, supplemental hand watering of each individual lysimeter was accomplished to bring each back to field capacity following each irrigation event.

A table of the average ratio of measured turfgrass evapotranspiration to calculated ETos over the growing season is presented in the Summary.

Keywords. Turfgrass ET, weighing lysimeter, plant factor, crop factor, deficit irrigation.

Procedures

Background

The direct measurement of turfgrass ET using weighing lysimeters provides a defensible basis for quantifying and comparing actual water use to ETos from the standardized Penman-Monteith equation. This information will assist in the programming of weather-based SMART controllers. It can also be utilized by municipalities to develop landscape irrigation standards in support of efficient water use and conservation.

A previous paper by Crookston, et al. (2010) included an overview of several previous studies regarding turfgrass ET. A second paper by Crookston, et al. (2011) included preliminary results from the 2011 season.

Methods

In 2009, Northern Water commenced construction and installation of a 30-ft x 30-ft study plot for turfgrass lysimeters within its Conservation Gardens at its headquarters in Berthoud, Colorado. The turfgrasses were seeded starting May 28, 2010, and finishing June 2, 2010. However, frequent sprinkler irrigations for establishment of the turfgrasses continued through most of July 2010. The top rim of most lysimeters was still clearly visible and the effective diameter of the lysimeters did not fill the small gap surrounding all lysimeters until after that time. Consequently, the 2011 season was the first full season for evaluation of ET from established turfgrasses.

The lysimeter plot was divided into 4-ft x 4-ft sub-plots, separated by 1-inch x 6-inch PVC plastic composite decking/edging material. This edging clearly delineated the subplots and helped prevent the spread of one grass variety into another subplot. It also provided support for foot traffic by study technicians without damage to turf or compaction of the soil. Turfgrasses were planted into 44 of the 49 sub-plots. The four corners and center sub-plots were not included in the study, but were planted to a bluegrass blend to maintain fetch. The lysimeter plot was divided into four blocks, with each block containing 11 randomized sub-plots with lysimeters, one of each turfgrass variety initially included in the study. However the Ephraim crested wheatgrass did not thrive and by 2012 was significantly contaminated by adjacent grasses. It was subsequently dropped from consideration. Consequently, the study included four replicates of each of the following 10 turfgrasses:

Table 1. Turfgrasses (seed mix by weight)

Blue gramma – buffalograss mix	70% Blue Gramma & 30% Buffalograss
Drought hardy Kentucky bluegrass	33% Rugby, 33% America & 33% Moonlight
Fine fescue mix	25% Covar Sheep, 25% Intrigue Chewings, 25% Cindy Lou Creeping Red & 25% Eureka Hard
Kentucky bluegrass blend	50% Rampart, 25% Touchdown & 25% Orfeo
‘Low Grow’ mix	29% Creeping Red fescue, 27% Canada bluegrass, 24% Sheep fescue & 16% Sandburg bluegrass
‘Natures Choice’ mix (Arkansas Valley)	70% Ephraim Crested wheatgrass, 15% Hard fescue, 10% Perennial ryegrass, 5% Kentucky bluegrass
Perennial ryegrass	Playmate blend
Reubens Canada bluegrass	
Tall fescue	Major League blend
Texas hybrid bluegrass blend	50% Reveille & 50% SPF 30

Equipment

The weighing platform for each lysimeter includes a Revere PC6-100kg-C3 load cell transducer. Each load cell is connected to one of three AM 16/32 multiplexers, each connected to a Campbell Scientific CR10X data logger. Every three seconds a measurement is taken from each load cell. These measurements are averaged every 60 seconds. This 1-minute average is time-stamped and stored in the data logger at the end of each 15-minute period. Stored data is automatically downloaded every 15 minutes to a desktop PC via an RF401 spread-spectrum radio. Differences in lysimeter weight are calculated as the difference in the measurement at the end of each hour. These hourly values are compared to calculated ETos obtained from the REF-ET software v.3.1.08 (http://www.kimberly.uidaho.edu/ref-et/) utilizing data from the adjacent Campbell Scientific ET-106 weather station. The weather instruments are each calibrated annually.

The weighing platforms for each lysimeter were calibrated in-place (without the lysimeters) in September 2009 over their full load range using steel weights. The platforms were again re-calibrated in-place during 2010, but only over their operational range (from dry soil to wet soil). In-place re-calibration was again performed in early March 2011. No problems were identified during the re-calibrations, and all weighing platforms were measuring lysimeter weights properly.

The entire lysimeter plot is on a single irrigation zone using MP Rotator 2000 sprinklers on 15-ft spacing. A DLJ ¾-inch x ¾-inch brass flow meter with pulse output is connected to a Campbell Scientific data logger which measures all irrigation applications to the lysimeter plot. In addition, 15 Texas Electronics tipping bucket rain gauges are installed flush with the turf height throughout the lysimeter plot to measure net irrigation application as well as rainfall.

Deep Percolation Effects Excluded

Deep percolation down through the lysimeters was not directly measured. Beginning in late July 2010, all sprinkler irrigations were scheduled for after sundown and before midnight. Because the lysimeters are free-draining with sandy loam soil only 20-inches deep, any deep percolation from irrigation was generally assumed to be completed within 24 hours. Hand watering to bring each individual lysimeter subplot up to field capacity almost always occurred the same day as the sprinkler irrigation, or the following day. The data following an irrigation event or significant rainfall was discarded from the analysis. Minor rainfall events were included, but with the calculated daily ET increased by the amount of rainfall. Any excessive percolate that ponded below a lysimeter was removed through a manually-controlled vacuum extraction system as needed.

Results and Discussion

Table 2 provides the average ratio of measured turfgrass evapotranspiration to calculated ETos during the 2011 and 2012 seasons for each of the 10 selected turfgrasses. Figure 1 presents the same data graphically, but on a time scale of cumulative growing degree days from greenup as a percentage of the cumulative growing degree days from greenup to effective full cover (beginning of peak use period). As expected, these data clearly indicate reduced water use in the Spring season with peak water use occurring during mid-Summer. Although some differences between different turfgrasses are evident, these data are preliminary and should not be relied upon until further more in-depth analysis and additional seasons of data are included for evaluation.

Table 2. Cool Season Turfgrass Kc_{os}, preliminary data.

Calendar month	Blue gramma – buffalograss mix	Drought hardy Kentucky bluegrass	Fine fescue mix	Kentucky bluegrass blend	'Low Grow' mix	'Natures Choice' mix	Perennial ryegrass	Reubens Canada bluegrass	Tall fescue	Texas hybrid bluegrass blend
Mar	-	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.08	0.07
Apr	0.16	0.41	0.44	0.41	0.42	0.43	0.39	0.37	0.44	0.40
May	0.35	0.68	0.73	0.69	0.70	0.72	0.66	0.64	0.72	0.67
Jun	0.70	0.85	0.87	0.85	0.86	0.89	0.86	0.82	0.85	0.83
Jul	0.88	0.92	0.89	0.90	0.90	0.94	0.92	0.90	0.87	0.87
Aug	0.88	0.94	0.90	0.91	0.90	0.95	0.93	0.91	0.87	0.88
Sep	0.85	0.93	0.91	0.90	0.89	0.95	0.92	0.91	0.88	0.87
Oct	0.81	0.90	0.91	0.88	0.87	0.94	0.90	0.91	0.87	0.85
Apr-Oct	**0.66**	**0.80**	**0.81**	**0.79**	**0.79**	**0.83**	**0.80**	**0.78**	**0.79**	**0.77**

For use with ETos for established turfgrass stands, well-watered, and experiencing seasonal (winter) dormancy periods. Turfgrass Kc = Measured Turfgrass ET / ETos adjusted for Ks (soil moisture stress).

Figure 1 illustrates the procedures for normalizing Kc curves based on growing degree days. Under this timeline, the similarity of the Kc curves is striking. It provides more accurate application of Kc curves during different growing season, whether hotter and longer, or shorter and cooler than average. The 2012 season was significantly warmer and longer than cooler 2011 season, however the Kc data from both season compared closely to one another. Further detail is available from Allen 2007.

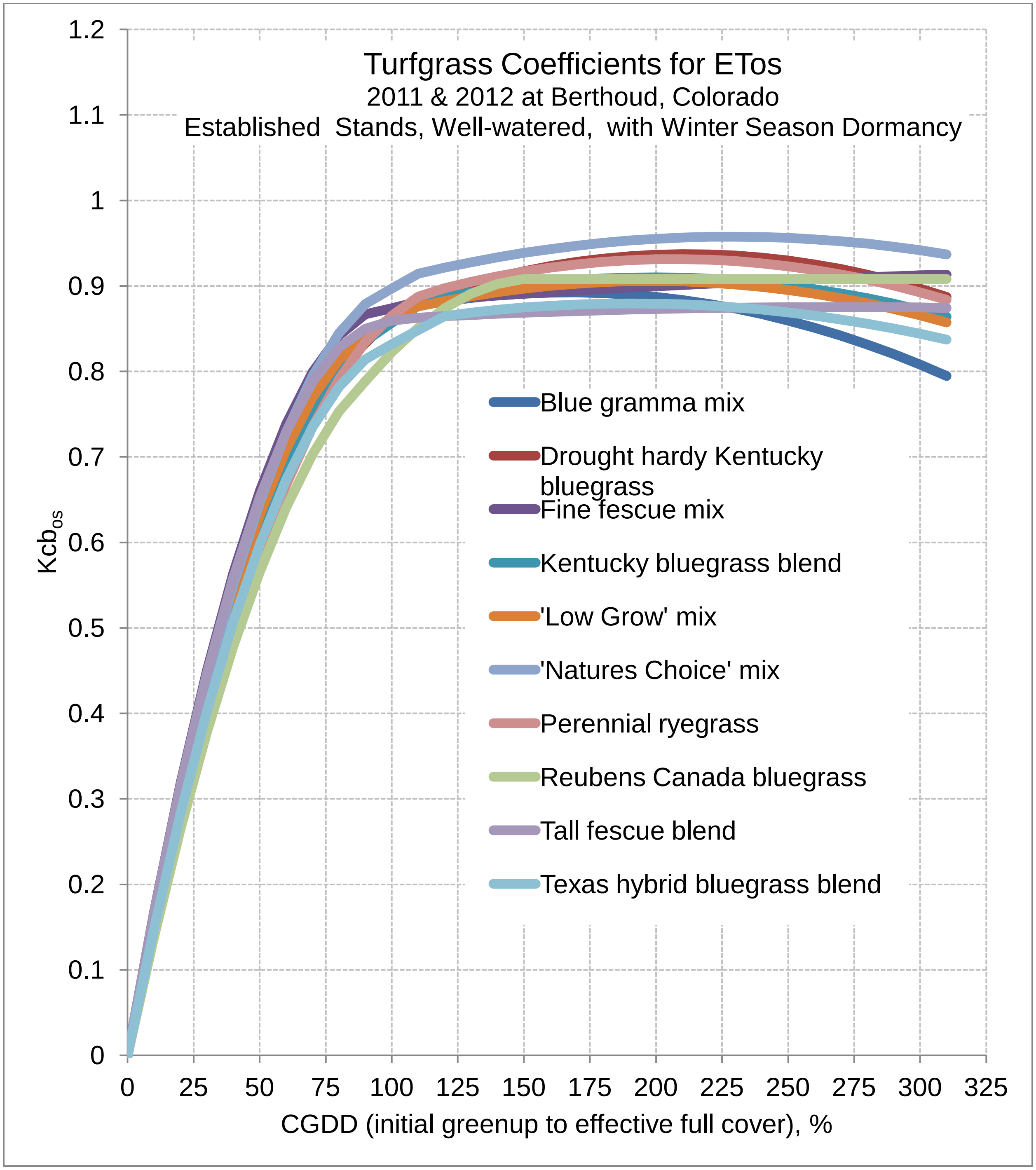

Figure 1. Small Turfgrass Lysimeters, 2011-2012, preliminary data. Average ratios of measured turfgrass ET to ETos for 10 turfgrasses in Northeastern Colorado. Turfgrass Kcb = Measured Turfgrass ET / ETos adjusted for Ks (soil moisture stress).
GDD = max((Tmax+Tmin)/2-Tbase,0) with Tmax, Tmin and Tbase in Deg C. Tbase = 0 and 10 for cool season and warm season turfgrasses respectively. CGDD (cumulative growing degree days) Greenup to Effective Full Cover = 1300 and 550 for cool season and warm season turfgrasses respectively.

Conclusions

Additional seasons of data collection are necessary to fully establish the plant water use coefficients for the various turfgrasses. Future plans include study of turf water use under deficit or significantly reduced irrigation management. It is anticipated this information will be of particular value in programming and adjusting irrigation controllers to adjust for the reduced water use of turfgrasses during the Spring season and to better maintain turfgrass vigor and health during the mid-summer period of greatest water need. Previous approaches utilizing a constant turfgrass coefficient all season can be readily improved, resulting in potential for increased water conservation and improved landscape appearance.

Acknowledgements

The high quality of the collected data for this study was directly attributable to the professionalism and work ethic of Ron Boyd and Chad Kuhnel. Both are employees of Northern Water, working in the Conservation Gardens and accomplished the majority of the work to construct, install and establish the lysimeter study plot.

References

Crookston, M.A. and M. Hattendorf 2010. Turfgrass ET from Small Lysimeters in Northeast Colorado. Presented at the USCID 2010 Fort Collins Conference, September 28 – October 1, 2010. Abstract on Page 51 (full paper on accompanying CD). Available from USCID, 1616 Seventeenth Street #483, Denver, Colorado, USA 80202, www.uscid.org.

Crookston, M.A. and M. Hattendorf 2011. Turfgrass ET from Small Weighing Lysimeters in Colorado: First Full Year Results. Presented at the Irrigation Show 2011 in San Diego, California, USA, November 7, 2011. Available from Irrigation Association, Falls Church, Virginia, USA 22042-6638, www.irrigation.org

Allen, R.G. and C.W. Robison 2007. Evapotranspiration and Consumptive Irrigation Water Requirements for Idaho, University of Idaho, www.kimberlyuidaho.edu/ETIdaho. Prepared under contract with the Idaho Department of Water Resources. A related paper: 'Updated Procedures for Calculating State-Wide Consumptive Use in Idaho' was presented by R.G. Allen at the USCID Fourth International Conference on Irrigation and Drainage in Sacramento, California, USA, October 3-6, 2007. Available from USCID, 1616 Seventeenth Street, #483, Denver, Colorado, USA 80202, www.uscid.org