FINAL REPORT

Leaching Requirements for Turfgrass Salinity Management and Water Conservation

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**Objectives:**

Our hypothesis for this study was that turf and other plants respond to water uptake weighted salinity and that root zone salinity is lower than expected due to the reduction in water consumption under stress. In other words, existing models over predict the leaching fraction or amount of water required to leach salts through the root zone for salinity management. The broad goals of our research were to demonstrate that, with proper management, turf is a suitable crop for irrigation with recycled water, and substantial water savings can be achieved on turfgrass sites by proper irrigation water management.

**Study Conditions:**

The study area was located in Riverside, CA on a fine sandy loam seeded with perennial ryegrass ‘SR 4550’ on 28 April 2011. The turf was irrigated with potable water (EC = ~0.6 dS/m) until fully established (Fig. 1). The turf was mowed twice/week at 2.5 inches and received approximately 0.5 lb N/1000 ft$^2$/month using a complete fertilizer (N-P$_2$O$_5$-K$_2$O). On 21 July 2011, saline irrigation was initiated on half of the study by mixing salts in two 5000-gallon storage tanks to achieve EC ~4.6 dS/m with a similar ion composition to that of water from the Colorado River. The study area was partitioned into four irrigation zones which were initially set up to apply 90, 110, 130, and 150% of reference evapotranspiration (ETo) based upon CIMIS ETo from the previous week. Within a couple of weeks, the irrigation was lowered to 80, 100, 120, and 140% ETo to account for overly wet conditions and lack of any observable salinity stress on the ryegrass turf (Fig. 2). Furthermore, we experimented with frequency of irrigation events to help combat wet conditions. Although irrigating every other day helped to reduce surface wetness, especially on days of mowing, it became apparent that daily irrigation was necessary to maintain perennial ryegrass health during the summer in Riverside.

The study area was composed of 12 main plots, each irrigated with water ranging from EC ~0.6 to ~4.6 dS/m. In the perpendicular direction, three main plots were irrigated at 80, 100, 120, or 140% ETo. To more precisely determine the effects of salinity on turfgrass health and underlying soil, we subdivided each of the 12 main plots into 9 sub-plots ranging from low to high irrigation salinity. Clippings were collected from each sub-plot every two weeks beginning with a baseline measurement shortly before the saline irrigation was initiated. Turf quality was also assessed every two weeks on a 1-9 rating scale, 1 = dead turf, 6 = minimally acceptable, and 9 = ideal. Toro Turf Guard TDR (time-domain reflectometry) sensors were placed at 4 and 8 inches below the soil surface in select plots representing low, medium, and high irrigation salinity. Irrometer suction lysimeters were placed at a 10-inch depth to extract leachate at periodic intervals.

**Results:**

- Water conservation on landscapes including turfgrass is a must in California and other arid regions of the country. As an example and assuming in Riverside, CA:
  - average annual crop coefficient (Kc) of cool-season turf = 0.8
  - average annual ETo = 56.4 inches
  - annual normal precipitation = 10.7 inches (25% available for turf use)
  - 70% irrigation efficiency
approximately 7,000 gallons of water are applied annually to maintain a 2,000 ft$^2$ stand of cool-season turf.

- Although preliminary, our results suggest that turfgrass (even species like perennial ryegrass with low to moderate salinity tolerance) can be irrigated with recycled water that is high in salinity (irrigation water with EC~4.6 is considered extremely high and rare, but not unheard of for some turfgrass sites in California) provided that proper management practices are employed. These include: 1) ensuring adequate drainage with grading, drainage installation, cultivation practices; 2) selection of species (warm-season grasses possess greater salinity and drought tolerance relative to cool-season grasses); 3) leaching to move salts out of the root zone to reduce salinity stress on the plant; and 4) minimizing plant stress during high temperatures including judicious mowing practices, traffic reduction, and avoiding soil moisture extremes.

- During the study period, very little perennial ryegrass turf was lost due to the salinity and/or deficit irrigation treatments. The greatest turf loss occurred on the lower end of the 140% ETo treatment area where standing water was almost always present. Other small areas of turf loss were later associated with extremely high salts (as high as 22.5 dS/m near a saline irrigation line in an 80% Eto plot) found in leachate collected 10 inches below the soil surface (data not shown). It is important to note that the study area received no traffic outside of mowing twice/wk. Poor drainage and high traffic are common causes of turf loss even when salinity is not a limiting factor. Furthermore, researchers in New Mexico recently completed a three-yr study that evaluated the effects of irrigation salinity up to 3.5 dS/m at 120% ETo on performance of several cool-season turfgrass species including perennial ryegrass (Sevostianova et al., 2011). By the end of the study, only tall fescue possessed acceptable turf quality. Thus, it is likely that we will see progressive ryegrass deterioration as this study is continued in future years.

- The most visible turf injury from salinity was noted in late August after a prolonged period of daytime temperatures near or exceeding 100F. Figure 3 shows the relationship between turf quality and irrigation water quality during that time. Using a value of 6 as an indication of minimally acceptable turf, Fig. 3 shows that irrigation at 140% ETo clearly produced the best turf quality over the entire range of irrigation salinity. However, the turf was so saturated in this area that it would be unusable other than for aesthetic purposes. On the other end of the spectrum, irrigation at 80% ETo produced unacceptable turf quality even with negligible salinity. These results are consistent with previous research on water requirements of cool-season turfgrasses as 80% Eto without any adjustments for irrigation distribution uniformity, etc. would be considered deficit irrigation in a climate like Riverside. Given the parameters of our study, irrigation water with EC in the upper range (~2.6-4.6 dS/m) appears to require irrigation replacement of approximately 120% ETo to maintain quality ryegrass turf, whereas irrigation water with EC in the lower range (~0.6-2.6 dS/m) requires less irrigation replacement in the neighborhood of 100% ETo.
• To determine the most accurate estimation of minimum irrigation requirements and salinity levels that provide acceptable turf quality and health in this study, we submitted soil and leachate samples from the plots to a laboratory for analyses of EC and other chemical properties to correlate with turf quality and clipping yield data. Turf quality and soil EC data for each irrigation regime are represented in Figures 4-7. Soil EC values from samples taken in Oct 2011 ranged from 2.12 to 6.44 dS/m for 80% Eto; 1.22 to 5.57 dS/m for 100% Eto; 1.74 to 5.43 dS/m for 120% Eto; and 2.2 to 5.11 dS/m for 140% Eto. In addition, EC of the leachate collected in September 2011 from 10 inches below the soil surface was as high as 22.5, 17.57, 14.83, and 14.4 dS/m for 80, 100, 120, and 140% Eto, respectively (data not shown). Overall, these data suggest a strong correlation among soil/water EC, leaching fraction, and turfgrass quality and performance. Comprehensive statistical analyses of 2011 data and continued experiments are planned to more accurately identify critical irrigation and salinity levels for turfgrass management and water conservation.

• Thanks to initial support provided by the Metropolitan Water District of Southern California, the Bureau of Reclamation, and the U.S. Salinity Laboratory, we are fortunate to be able to continue this project in 2012 and beyond with a new grant from the United States Golf Association.

**Summary:**

Turfgrass plays an important role in the landscape and in the lives of Californians. It is aesthetically pleasing and provides a safer, cushioned surface for sports and recreational activities. Turfgrass reduces surface temperature by transpirational cooling. It also lessens glare, noise, soil erosion, and dust thereby reducing air pollution and allergens. Turfgrass provides habitat for wildlife and reduces wildfire hazard. It has been demonstrated to be an effective biofilter for applied nutrients and pesticides, and for pharmaceuticals and other xenobiotics in recycled water for irrigation. Turfgrass can sequester approximately 2-3 times the amount of carbon from the atmosphere compared to agricultural crops. On an average managed lawn, turfgrass captures about four times the carbon from the air than the carbon output of a typical lawn mower. Last but certainly not least, turfgrass has a direct and significant impact on the California economy.

On the contrary, turfgrass can demand significant amounts of water, especially cool-season species like tall fescue and perennial ryegrass that require supplemental irrigation to maintain green color year round in a Mediterranean climate. California is running low on potable water resources and landscape plants, especially turfgrass, are likely to be the first to suffer the consequences unless changes are made toward proper irrigation practices in general, use of more drought tolerant species, and irrigation using recycled water where practicable.

The preliminary results of this research substantiate the use of recycled water on turfgrass for water conservation provided that salinity management practices are implemented. These practices include: providing adequate drainage, selecting proper turfgrass species, implementing proper cultural practices, and applying adequate water to leach salts through the root zone.
Whereas traditional leaching practices for managing turfgrass salinity have relied upon either mathematical models that may over predict leaching fractions or simply leaving the irrigation system on during the night to ensure adequate leaching, the objective of the initial phase of our research was to provide more precise estimates of leaching fractions based upon water quality, turfgrass species, soil type, and other factors. The end results are expected to conserve water, regardless of quality, in addition to providing healthier turf and improved quality of life for Californians.
Figure 1. Turfgrass salinity research area in Riverside, CA. Alternating irrigation lines are fed by potable (P) or saline (S) water. Two 5,000-gal tanks are used to store and deliver saline irrigation water. In the perpendicular direction, the area is divided into four irrigation zones, ranging from replacement of 80 to 140% ETo. Two subsurface drain lines bisect each of the irrigation zones with outlets for collection of leachate. Twelve 30-ft x 30-ft plots represent a continuous distribution saline and potable water at a given irrigation regime.
Figure 2. Standing water in the right foreground was indicative of high irrigation (140% ETo) that exceeded rate of infiltration (bottom of the slope). Arrow points to turf stress caused by temperature and salinity which was most noticeable in late August 2011 in the 80% ETo zone near the saline irrigation line
Figure 3. Perennial ryegrass turf quality on 31 August 2011 in response to irrigation water quality and regime. Values were averaged from three plots of similar irrigation water quality within each irrigation regime. Turf stress from temperature and salinity was most severe during this period of the study. Riverside, CA.
**Figure 4a.** Perennial ryegrass turf quality in response to irrigation water quality at 80% ET.<sub>o</sub>. Turf stress from temperature and salinity was most severe during these dates in 2011. Tick marks on x-axis represent sub-plots in between alternating saline and potable irrigation lines (shown from North to South in Fig. 1). Slope of plot area is oriented from right to left on the graphs.

**Figure 4b.** Soil EC (dS/m) at 80% ET.<sub>o</sub> on 6 October 2011. The x-axis is represented the same as in Fig. 4a.
**Figure 5a.** Perennial ryegrass turf quality in response to irrigation water quality at 100% ET$_o$. Turf stress from temperature and salinity was most severe during these dates in 2011. Tick marks on x-axis represent sub-plots in between alternating saline and potable irrigation lines (shown from North to South in Fig. 1). Slope of plot area is oriented from right to left on the graphs.

![100% ET$_o$ Turf Quality Chart](image)

**Figure 5b.** Soil EC (dS/m) at 100% ET$_o$ on 6 October 2011. The x-axis is represented the same as in Fig. 5a.

![100% ET$_o$ Soil EC Chart](image)
**Figure 6a.** Perennial ryegrass turf quality in response to irrigation water quality at 120% ET₀. Turf stress from temperature and salinity was most severe during these dates in 2011. Tick marks on x-axis represent sub-plots in between alternating saline and potable irrigation lines (shown from North to South in Fig. 1). Slope of plot area is oriented from right to left on the graphs.

**Figure 6b.** Soil EC (dS/m) at 120% ET₀ on 6 October 2011. The x-axis is represented the same as in Fig. 6a.
Figure 7a. Perennial ryegrass turf quality in response to irrigation water quality at 140% ET₀. Turf stress from temperature and salinity was most severe during these dates in 2011. Tick marks on x-axis represent sub-plots in between alternating saline and potable irrigation lines (shown from North to South in Fig. 1). Slope of plot area is oriented from right to left on the graphs.

Figure 7b. Soil EC (dS/m) at 140% ET₀ on 6 October 2011. The x-axis is represented the same as in Fig. 7a.
References: