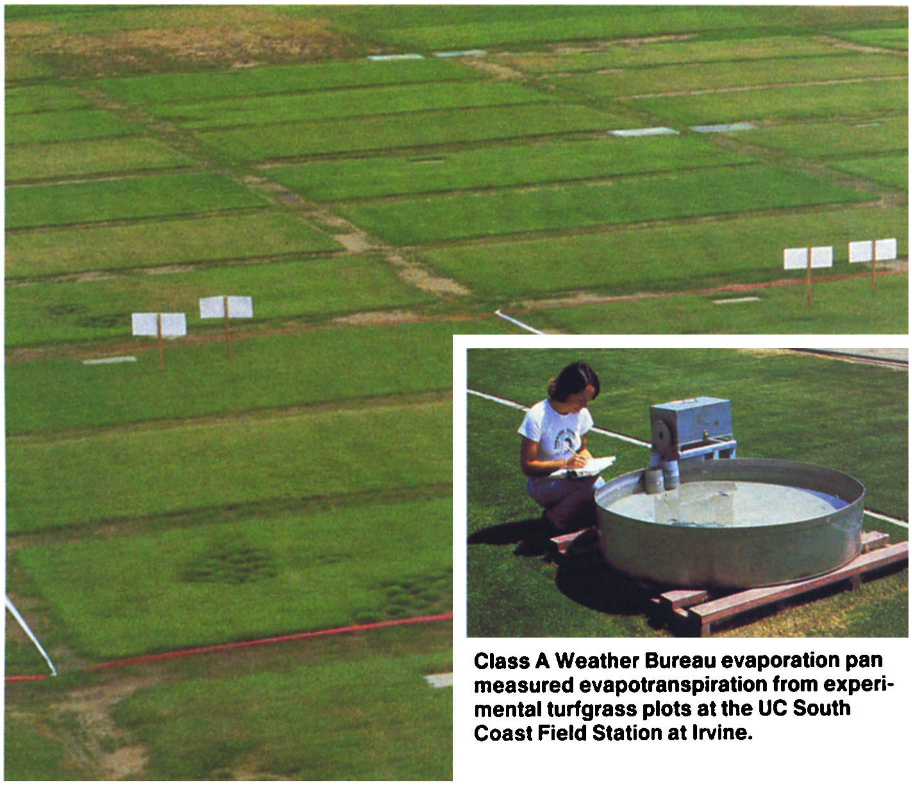

Class A Weather Bureau evaporation pan measured evapotranspiration from experimental turfgrass plots at the UC South Coast Field Station at Irvine.

Turfgrass performance under reduced irrigation

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Turfgrass in California requires irrigation during all or most of the year. Water restrictions imposed during the drought in 1976 and 1977 forced turf managers to reexamine many concepts about irrigation. Turfgrass managers had to make drastic cuts in water use and hope that the turf would survive. One significant result of the drought was the realization that lower levels of turf quality were acceptable in many situations and that large water savings could be achieved. No information was available, however, on the best conservation practices or on the minimum amounts of water needed to keep the turf alive.

Research was begun in 1979 to produce irrigation methodology that could be used to develop water-saving irrigation practices anywhere in California and in other arid and semiarid regions. The three-year study showed that major savings of water can be achieved, especially with warm-season grasses, with no appreciable loss of turf quality.

Turf-irrigation study

Specifically, the objectives of the research were to: (1) investigate the effects of applying reduced amounts of irrigation water calculated as a percentage of evapotranspiration of applied water on cool-season and warm-season turfgrasses; (2) evaluate a below-ground system as a potentially more efficient method of turf irrigation than standard sprinkler application; and (3) develop a set of crop coefficients that California turfgrass managers can use to determine on-site water use by both cool- and warm-season turfgrasses.

The study was conducted at the University of California South Coast Field Station, Irvine. The variables tested included: two irrigation methods, sprinkler application of water and a subterranean or buried trickle/drip water application (8-inch depth, 23-inch spacing); three irrigation regimes, 100, 80, and 60 percent of calculated evapotranspiration; and six commonly used turfgrasses, three cool-season varieties (Kentucky bluegrass, perennial ryegrass, and tall fescue) and three warm-season types (hybrid bermudagrass, zoysiagrass, and Seashore Paspalum).

The field plot was a randomized split-block design. The area was divided into two turf blocks, one for cool-season grasses and the other for warm-season grasses. Each block consisted of four replications, and within each replication were six randomized irrigation plots measuring 15 by 24 feet. Irrigation plots were divided into three turf subplots of 8 by 15 feet. The three sprinkler and three subterranean irrigation plots per replication were installed in September 1979 for above- and below-ground water application. Each sprinkler irrigation plot contained six high-pop brass sprinkler heads designed to apply 10 gallons of water per minute at a pressure of 35 pounds per square inch. The coefficient of uniformity was 87 percent.

Tensiometers at 3- and 6-inch depths in the cool-season grasses and 8- and 12-inch depths in the warm-season grasses indicated soil water status; neutron probe access tubes were installed in plots to a depth of 4 feet in the cool-season and 6 feet in the warm-season grasses. Scheduling was by the water budget technique calculated weekly using wind-modified pan evaporation data. State-of-the-art controllers were programmed with this irrigation scheduling information. The amount of irrigation was modified so that water did not pass below the 4-foot and 6-foot depths of the neutron probe access tubes during the irrigation season.

Annual crop coefficients, determined from previous research using applied water and evaporation pan data, were 0.7 annually for warm-season grasses and 0.8 for cool-season grasses. Monthly crop coefficients were developed in this experiment to evaluate responses of the six turfgrass species to 60 percent and 80 percent of replacement evapotranspiration for water conservation.

Turf performance

Overhead sprinkler irrigation provided acceptable performance of some turfgrass species, even when less than the optimum amount of water was applied. Subterranean irrigation did not provide acceptable turf with the shallow-rooted cool-season species, at the system depth and spacing used in this study. The very deeply rooted hybrid bermudagrass was the best-performing species with subterranean irrigation.

Under sprinkler irrigation, there was no significant difference in cool-season grass performance between the 100 percent and 80 percent regimes (table 1). This could be described as a potential level of water conservation amounting to 21.1 percent savings (77.2 inches versus 61 inches). The savings could be tenuous, however, because of more weed and disease activity (such as Gerlachia patch on Kentucky bluegrass) when irrigated with less than the optimum amount of water. The 60 percent regime significantly reduced the turf quality of the three cool-season grasses tested.

In the warm-season grasses, the appearance of hybrid bermudagrass and Seashore Paspalum was not significantly different under any of the irrigation regimes. As irrigation amounts were reduced, zoysiagrass appearance ratings declined because of nematode activity observed on the roots. Both Santa Ana hybrid bermudagrass and Adalayd (Excalibre) Seashore Paspalum had very good color, density, texture, uniformity, and freedom from weeds and diseases, irrespective of irrigation regimes. Clearly there is potential for considerable water savings with these grasses. This study showed a 40 percent reduction in actual water applied between the optimum and lowest irrigation regime (65.5 versus 39 inches).

Because of the field plot design necessary for this study, it wasn't possible to compare statistically the turf performance results between the warm- and cool-season grasses. Hybrid bermuda and Seashore Paspalum performed very well, however, with 52.7 inches of water applied (60 percent irrigation regime), whereas the cool-season grasses needed at least 82.4 inches (80 percent irrigation regime). Thirty-six percent less water was applied to the warm-season species than to the cool-season species for acceptable turf quality. If applied water in the 60 percent irrigation treatment in warm-season grasses (52.7 inches) is compared with that in the 100 percent treatment in cool-season grasses (104.4 inches), the saving in water is 49.5 percent.

Water application

The cool-season grass in the 100 percent regime received 43 inches of water in 1982 (table 2). Warm-season grasses received only 34 inches. Rainfall of 18.45 inches occurred primarily from November to March. The soil profile held about 10 inches depth of water in the top 6 feet. Rainfall did not appreciably affect the applied water during the primary growing season, April through November. Likewise, the 34 inches applied to the warm-season grasses was not appreciably affected by, nor was there evidence of, deep percolation during the primary growing season, when only 4 inches of rain fell. The rainfall is subtracted from the original evaporation pan reading and is therefore reasonably accounted for in the calculated applications.

In 1983, a higher than normal rainfall of 32 inches occurred. The soil profile was filled during the winter, however, and only 9 inches of rain fell from April to October 30, of which 4 inches occurred in early April. Water moved below the root zone only on June 29, August 29, October 5, and October 17 in all plots of 100 and 80 percent irrigation in 1983. Even during a season of higher than normal rainfall, the applied water, 38.7 inches in cool-season grasses (1983), was similar to that of the drier year (1982) with 43 inches applied. Most of the 5 inches of implied higher use by cool-season grasses may have moved through deep percolation.

The water applied to warm-season grasses was 34 inches in 1982 and 33 inches in 1983. This small difference indicates that managers can schedule carefully and conserve water in a wet or dry season.

TABLE 1. Cool- and warm-season turfgrass appearance ratings and water applied for the duration of the study (August 1981 to December 1983).

Irrigation regime	Turf appearance 8/81 - 12/83*			Water application (actual)	ET_{grass}†
% of ET				*in.*	
Cool season	Ken. blue	Per. rye	Tall fesc.		
100	5.5 y	6.2 y	5.8 y	104.4	77.3
80	5.3 y	5.9 y	5.7 yz	82.4	61.0
60	4.8 z	5.0 z	5.3 z	62.7	46.4
Warm season	Bermuda	Paspalum	Zoysia		
100	6.5 ns‡	5.8 ns	5.6 x	88.4	65.5
80	6.5	5.8	4.8 y	69.4	51.4
60	6.4	5.4	4.2 z	52.7	39.0

* Rated on a scale of 1 to 9, with 1 indicating worst appearance and 9 best. Values followed by common letters are not significantly different at the 5% level of probability.
† ET_{grass} equals the actual applied water divided by the extra water factor (EWF_{90}), which is 1.35.
‡ No significant difference.

TABLE 2. Actual water applied in 1982 (1/1/82 to 12/31/82) and 1983 (1/1/83 to 12/31/83)

Sprinkler plots	1982 Water applied*	1982 Rainfall	1983 Water applied†	1983 Rainfall
% of ET	*inches*			
Cool season				
100	43.2	18.45	38.7	31.78
80	35.0		31.9	
60	26.6		24.5	
Warm season				
100	34.0		33.0	
80	27.4		25.8	
60	21.6		19.6	

* Class A pan evaporation 55.0 inches for 1982.
† Class A pan evaporation 55.63 inches for 1983.

TABLE 3. Turfgrass crop coefficients (Kp and Kc) of warm- and cool-season grasses.

Month	Kp* Warm	Kp* Cool	Kc† Warm	Kc† Cool
J	.44	.49	.55	.61
F	.43	.51	.54	.64
M	.61	.60	.76	.75
A	.58	.83	.72	1.04
M	.63	.76	.79	.95
J	.54	.70	.68	.88
J	.57	.75	.71	.94
A	.57	.69	.71	.86
S	.50	.59	.62	.74
O	.43	.60	.54	.75
N	.46	.55	.58	.69
D	.44	.48	.55	.60

* Monthly crop coefficient (Kp) is used with a Class A Weather Bureau evaporation pan with the equation $ET_{grass} = ET_{pan} \times Kp$
† The crop coefficient Kc is used with reference evapotranspiration (ETo) from a CIMIS weather station with the equation $ET_{grass} = ETo \times Kc$.

Conclusions

The monthly crop coefficients (table 3) calculated and used for nearly three years proved to be very accurate for both warm- and cool-season turfgrasses. Crop coefficients can be used with reference evapotranspiration from the Department of Water Resources California Irrigation Management Information System (CIMIS) program. Turfgrass managers can use these crop coefficients to determine on-site water use by turfgrasses from either a Class A Weather Bureau evaporation pan or from a computerized weather station that gives reference evapotranspiration with the equation given in table 3.

In conclusion, warm-season turfgrasses have a greater potential for water conservation than do cool-season turfgrasses. Under the conditions of this study, sprinkler irrigation was superior to subterranean irrigation for water conservation and turfgrass performance. And lastly, a well-designed, uniform irrigation system is necessary to maximize water conservation in turfgrass management.

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