Automatic turf irrigation showing instrument area and cans set out to measure water distribution.

Evapotranspiration for Turf Measured with Automatic Irrigation Equipment

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Automatic irrigation, controlled by instruments capable of detecting moisture needs of plants, has been successfully used to study evapotranspiration rates for turfgrass at Riverside. Tests indicated that frequent, automatic sprinkling with relatively low-volume applications per irrigation might allow easy measurement of evapotranspiration. Tensiometers, acting as hydrostats, can turn "on" irrigation water when needed, but unpredictable flow rates in soils make it necessary to use a separate timing mechanism to set the duration or amount to be applied and turn the water off. Automatic irrigation management programs are now feasible, under many conditions, using tensiometers or other instruments responding to an energy variable of water in the soil. However, to be accurate for evapotranspiration measurements, such procedures should account for water losses below the rooting depths in the soil.

TENSIOMETERS measuring soil water conditions have been in use since about 1935 and the principles of automatic irrigation using a tensiometer were established as early as 1943. Commercial development of fully automatic irrigation has progressed first in connection with systems for irrigating turf and ornamental plantings. One such system, available for about 10 years, uses a tensiometer-type hydrostat to indicate a need for irrigation and a small electric clock motor to control the time of day or night when water is to be applied. The duration of irrigation on each of several pipeline sections is independently controllable.

This study was conducted on a 120 × 220-foot turf plot located south of a large intramural field at the University's Riverside campus. Asphalt parking and play areas occupy portions of the east and west sides. To the south is a relatively wide expanse of trees and turf plantings. The immediate turf area is enclosed by shrubbery borders which are watered from separate irrigation lines.

The regular sprinklers on the north half of the area were capped in July, 1961, and a separate irrigation system was installed using gear-driven rotary pop-up sprinkler heads. The porous cup of the hydrostat was located at an average depth of 3½ inches. When soil suction exceeded 20 centibars at this depth, a one-hour sprinkling was started at 2 a.m. At each irrigation, an average of ½ inch of water was applied automatically by meter readings. The south half was irrigated from a semiautomatic system operating the sprinklers for a specified period each night when turned on manually. A separate meter was installed to measure the water used under this system.

Automation evaluation

To evaluate the automated control, tensiometers were installed at five depths in two locations selected for average turf vigor. Cans were used to measure the depth of water applied at the two instrument areas and near the hydrostat. One instrument area and the hydrostat area received similar amounts of water, although less than the average for the area as a whole. Water application at the hydrostat and instrument areas was thus measured eleven times directly, and the ratio of application depth to meter reading was obtained. The average ratio was then used to convert the monthly water use, as read on the meter, to the depth of water applied at the hydrostat and instrument areas. Early morning timing reduced the effects of wind on the sprinkler distribution pattern to a minimum.

The table shows monthly irrigation applications for a full year. It also includes rainfall and air temperature records from the Citrus Research Center Weather Station located about one mile away. Correcting the total metered values to the amounts of water applied at the instrument area, and adding the rainfall, gives a reasonable approximation of the monthly evapotranspiration for turf.

Tensiometers with cups located at 1½-, 3-, 6-, 12-, and 20-inch depths were read daily between 4 and 5 p.m. The readings indicated that the major amount of root activity was in the upper 4 inches of soil. Readings from the two shallower depths showed wide variations. Usually these instruments would read 10 to 15 centibars on the day following an irrigation and would read values above 50 on the evening before an irrigation.

During August, there were occasional days when suction values at these depths exceeded the range measurable with tensiometers. Since only 0.35 inch of water was applied at the instrument area per irrigation, very little day-to-day change in the readings occurred at the 12- and 20-inch depths. However, starting in July and continuing through August, values at the 12-inch depth slowly increased from 7 to about 40 centibars. With more moderate weather conditions in September, readings at the 12-inch depth gradually decreased. By the end of November, values at this depth were similar to those during the first six months of the year.

Some adjustment in monthly evapotranspiration values might be justified because of water storage changes in the soil profile, but the amounts added to the July and August periods would in turn need to be subtracted from the September and October values. The total change of water stored in the 4- to 16-inch layer of soil, based on laboratory data, was estimated to be about ½ inch.

Flow velocity

While flow velocity of water through the profile cannot be measured explicitly, some indication of its direction was obtained by evaluating the hydraulic gradient tending to cause flow. Values of the hydraulic gradient between the 12- and 20-inch depths were such that downward flow occurred from January through June. Monthly means of daily values varied from 0.5 to 0.05. Values for July indicated flow was upward and the monthly mean hydraulic gradient was 21 for the month of August. Values indicating upward flow were 8 for September, 2 for October, and 1 for November. During December, the hydraulic gradient showed downward flow. Conductivity values for the decomposed granitic subsoil, estimated from laboratory measurements, indicated that total flow, between the 12- and 20-inch depths for any one month, probably did not exceed 0.1 inch. Again no attempt was made to correct the amounts of applied water for this transfer in the soil profile.

A 14-inch diameter insulated evaporation pan was installed in August with the water elevation about level with the turf. Evaporation values for the last four months of the year are included in the table. All of the measurements indicated were made while the irrigation program was completely under automatic control.

The automatic controller called for irrigation over 100 times during the year. This frequent irrigation with relatively low volume applications per irrigation appears to be well adapted for making evapotranspiration measurements. With relatively few additional modifications, this approach could be used to measure evapotranspiration for the wide range of conditions under which turf is being grown.

MONTHLY IRRIGATION APPLICATIONS AND VALUES CORRECTED FOR NONUNIFORM DISTRIBUTION OF WATER BY SPRINKLERS, INCLUDING RAINFALL AND AIR TEMPERATURE DATA FROM THE CITRUS RESEARCH CENTER WEATHER STATION

1962	Depth of water from meter readings, inches		Depth of water on instrument area, inches	Rainfall, inches	Evapotranspiration, inches	Mean monthly air temperature °F	Evaporation, inches
	Without hydrostat control	With hydrostat control					
January	2.14	2.17	1.4	1.9	3.3	53	
February		0.57	0.4	3.7	4.1*	51	
March	0.78	2.71	1.8	0.8	2.6	51	
April	8.64	7.76	5.2		5.2	64	
May	9.34	7.45	5.0	0.3	5.3	62	
June	9.16	7.35	4.9		4.9	68	
July	11.35	8.61	5.7		5.7	74	
August	11.96	8.36	5.5		5.5	77	8.5†
September	11.63	5.90	3.9		3.9	73	6.5
October	4.52	4.03	2.7		2.7	64	4.3
November	4.78	3.01	2.0		2.0	60	2.7
December	3.71	2.63	1.7		1.7	54	2.4
Total	78.01	60.55	40.2	6.7	46.9		

* Rainfall probably exceeded evapotranspiration for February.
† Estimated from measurements for only half of August.

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