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Water Requirements of Florida Turfgrasses [1]

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Introduction

Water is an essential component for plant growth. It comprises 80 to 90 percent of the fresh weight of turfgrasses (3). Water provides structure for plants by turgor pressure in cells which results in plant rigidity and cell elongation. Water plays a fundamental role in plant metabolism, both as part of many biochemical reactions and as a medium for dissolving organic and inorganic compounds. Water is also the transport medium for distributing substances throughout the vascular system of the plant, including nutrients absorbed by the roots and carbohydrates manufactured in the leaves (12, 15).

Only one percent of the water absorbed by plants is utilized for metabolic activity. The vast majority of water absorbed is used for transpiration. This is a plant process in which water is absorbed by the roots, passed through the vascular system, and exited from the plant via stomata into the atmosphere. Transpiration helps maintain plant temperatures by cooling through the latent heat of vaporization. The water absorbed by the plants in the transpiration process also brings nutrients from the soil into the plant (12, 15).

Evapotranspiration

Evapotranspiration (ET) is a process by which water is transferred to the atmosphere from vegetative surfaces. ET consists of two components, evaporation and transpiration. Evaporation is a physical process by which water is changed from a liquid to a gaseous state. Evaporation takes place from free water surfaces such as ponds, streams, wet soil, wet thatch, or wet vegetation. Transpiration, the other component of ET, is a plant process of water loss.

For most practical purposes it is impossible to separate the evaporation and transpiration components of water loss from turf surfaces. Therefore, the term evapotranspiration is usually employed in discussions. Also because the amount of water used in metabolic activities is negligible, evapotranspiration can be considered to be the same as consumptive water use by turfgrasses.

The amount of water transferred into the atmosphere by evapotranspiration from turf surfaces is governed by a number of environmental factors. Radiant energy (sunlight), atmospheric vapor pressure (relative humidity), temperature, wind, and available soil moisture supply are the controlling elements (7, 21). The type of warm-season turfgrass and how it is managed contributes only minor differences to the

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amount of ET if the grass is actively growing and has sufficient water (4). In fact, large turf areas generally have similar ET rates compared to that of citrus groves or forests (16). This points out that the environment (incoming solar energy) is the controlling force, not plant species, provided there is a continuous canopy or coverage of the soil surface. Minimal ET rates occur when there are dark, cloudy days with high relative humidity, low temperatures, and no wind. Maximum ET rates occur on bright sunny days with low relative humidity, high temperatures, and moderate to high winds. Normally in central and south Florida, May has the highest ET rates, and December has the lowest ET rates because of these factors (14).

Measurement of actual consumptive water use is an extensive and labor intensive task involving the use of lysimeters (21, 23, 29). Few of these facilities exist for this type of turfgrass water research in the United States. Studies in Arizona (11), Florida (25), Hawaii (8), and Nevada (27) have shown similar water usage for bermudagrass under summer conditions.

Studies by Stewart et al. (24, 25) at the Agricultural Research and Education Center, Fort Lauderdale, examined several factors affecting the evapotranspiration of St. Augustine grass and bermudagrass. Their studies were conducted over a five-year period using controlled water table lysimeters. St. Augustine grass and bermudagrass had similar evapotranspiration rates during the studies. Table 1 summarizes the observations of actual turf water use at Fort Lauderdale.

Potential Evapotranspiration

The concept of potential evapotranspiration has been developed to predict water requirements of plants based on limited climatic data. Potential evapotranspiration (ETP) is defined as the water loss from a continuous surface of turf which fully shades the ground, exerts little or no resistance to the flow of water into the atmosphere, and always has an adequate supply of soil water (6, 2 I, 31). ETP cannot exceed free water evaporation under the same weather conditions. Under most circumstances actual evapotranspiration is less than potential evapotranspiration because one or more of the conditions in the definition restricts the flow of water into the atmosphere.

Potential evapotranspiration is useful in predicting the water requirements of turf grown under irrigation. Because the actual on-site measurement of ET is often impractical or impossible, empirical methods have been developed to estimate water use. These methods rely on climatic data for predicting water needs on a per day, month, or year basis.

Thornthwaite (26), Penman (19), and Blaney-Criddle (5) methods are common empirical procedures for calculating potential evapotranspiration. Numerous other methods have been developed for specific crops and locations (7, 10). Each of these methods makes basic assumptions on the correlation between the climatic data used and how the crop responds under those conditions used to predict potential evapotranspiration. Formulas vary in their predictive ability depending on the assumptions and original data used to derive the empirical equation.

The Thornthwaite equation for predicting ETP utilizes temperature and day length data (26). It is a simple method, but has significant errors in short term prediction. The Blaney-Criddle method uses a consumptive use coefficient, temperature, and percent daylight to predict monthly ETP (5). This is a popular method for estimating ETP, and its accuracy depends on the proper coefficient and light levels. The Penman equation predicts daily ETP based on net radiation, vapor pressure, and wind speed. This method has been found to consistently underestimate water loss under conditions of strong sensible heat advection (20).

For accurate calculation of ETP, it is important to use observed environmental data in the equations. Significant errors can result if estimates or another location's data are used. Some methods require data such as net radiation, which few facilities have the equipment to measure. When using equations for estimating ETP in several locations within a wide geographical region, one should select a method that can be used with data collected from each location.

McCloud's Formula: $ETP = KW^{(T-32)}$

Where:

K = 0.01, W = 1.07, and T = mean temperature in °F

McCloud (13) developed an equation for predicting potential evapotranspiration, which reflected turfgrass water use under Florida conditions. As McCloud noted, most formulas tend to underestimate water use when the mean temperature is over 70° F

In Florida more than half of the months have average temperatures above 70° F, and in some locations the monthly mean temperature is above 80° F four months of the year (9). Utilizing Thornthwaite, Penman, or Blaney-Criddle methods under these conditions can lead to significant underestimation of potential evapotranspiration.

Figure 1 shows a comparison of the McCloud, Penman, and Thornthwaite methods of calculating potential evapotranspiration for Miami, Florida. All methods show similar ETP rates in the winter and early spring where monthly temperatures are less than 70° F As monthly temperatures in late spring and summer increase above 70° F, Penman and Thornthwaite ETP rates level off, while McCloud ETP rates continue to reflect the increasing temperatures. Practical experience has shown that irrigation requirements can approach McCloud's predicted rates if rainfall does not occur at regular intervals and amounts during the summer. If rains occur on a frequent basis in amounts less than one inch, then irrigation amounts will follow trends similar to Table 1 because high humidity and cloud cover reduce ET. Keeping in mind the definition of potential evapotranspiration, and to more accurately reflect Florida's environmental conditions, McCloud's Formula appears to be a better predictor of turfgrass water use. When weather monitoring facilities across the state begin collecting environmental parameters, such as net radiation, relative humidity, cloud cover, or others, then other ETP predicting methods may prove more suitable.

Turfgrass Irrigation Systems

Turfgrass in Florida is commonly irrigated with overhead sprinkler systems. These systems are

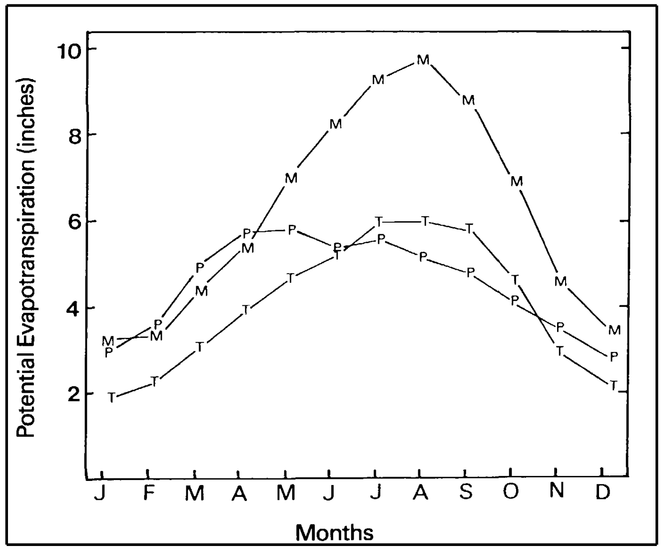

Figure 1 .

permanently buried in the soil and consist of sprinkler heads, pipes, fittings, valves, and controllers. Numerous differences exist among sprinkler systems due to differences in manufactured parts, system design, and installation. Sophistication and automation of a sprinkler system are closely related to the price of installation. Specific details on sprinkler system design, construction, and operation are given by Watkins (30) and Sarsfield (22).

Regardless of the sprinkler system, a person needs to know a few basic details about the performance of the system in order to efficiently apply water. First, one should know the irrigation rate of the system, in inches (centimeters) of water applied per hour. This can be easily determined by calibrating the sprinkler system (1). Next, one needs to know when to water, how much water to apply, and the method of applying water. Specific irrigation instructions can be found in Watering Your Florida Lawn (2).

Efficient water use and conservation of irrigation water are the responsibility of the system operator and require knowledge of turfgrass water requirements and sprinkler system capabilities. Proper turfgrass management practices are also essential in making the most effective use of rainfall and applied irrigation. Information on Florida turfgrass culture is available at all county extension offices.

Utilizing Irrigation Requirement Tables

Irrigation requirements (Table 2, Table 3, Table 4, Table 5, Table 6, Table 7, Table 8, Table 9, Table 10, Table 11) found in this publication were computed following the methods reported in *Irrigation Water Requirements* by the United States Department of Agriculture (USDA) Soil Conservation Service (28). These tables are meant to be used as a guide for planning turfgrass irrigation in various locations throughout Florida. Information contained herein reflects the need for irrigation based on historical climatological data and probability of these occurrences.

Mean monthly temperature and rainfall data presented are for the official weather station in each location and are from reporting periods averaging 52 years in duration (17). The mean monthly temperature data was used to calculate potential evapotranspiration by McCloud's method as previously discussed.

Net irrigation requirement (NIR) is the amount of water which irrigation has to supply to meet turfgrass consumptive demands. Net irrigation requirements were calculated making several basic assumptions. First, there was no carryover from month to month because of low moisture-holding capacity of sand soils, and the relatively shallow turfgrass root systems. Second, rainfall was adjusted for frequency distribution of effective rainfall. This provided an estimation of the portion of the total monthly rainfall used by turf for eight out of ten years. Net irrigation requirements were then determined by the difference between potential evapotranspiration and effective rainfall.

Losses of irrigation water do occur by evaporation, percolation, and runoff and therefore more water needs to be applied to achieve NIR levels. Gross irrigation requirements are the amounts of water that must be applied to meet NIR levels. Gross irrigation requirements are calculated by dividing net irrigation requirements by an application efficiency factor. Water losses in irrigated turf can be controlled so that losses are primarily from evaporation. Application efficiencies range from 60 to 95 percent, and depend upon wind speed, relative humidity, and temperature (18). Efficiencies can be maximized by irrigating when evaporation rates are the lowest, namely in early morning when there is no wind, relative humidity is high, and temperatures are low.

The environment of Florida provides a challenge to planning an efficient turfgrass irrigation program. Use of these tables will help provide general turf water requirements throughout the state of Florida. Careful planning and proper irrigation practices will conserve this valuable resource and provide good quality turfgrass.

Literature Cited

1. Augustin, B. J. 1981. How to calibrate your sprinkler system. Fla. Coop. Ext. Serv. Fact Sheet OH-61.

2. Augustin, B. J. 1981. Watering your Florida lawn. Fla. Coop. Ext. Serv. Fact Sheet OH-9.

3. Beard, J. B. 1973. Turfgrass: science and culture. Prentice-Hall. Englewood Cliffs, NJ.

4. Biran, I., B. Bravdo, I. Bushkin-Harav, and E. Rawitz. 1981. Water consumption and growth rate of l 1 turfgrasses as affected by mowing height, irrigation frequency, and soil moisture. Agron. J. 73:85-90.

5. Blaney, H. F. and W. D. Criddle. 1950. Determining water requirements in irrigated areas from climatological data. U.S.D.A. Soil Conservation Service Tech. Pub. 96.

6. Campbell, G. S. 1977. An introduction to environmental biophysics. Springer-Verlag. New York.

7. Chang, J. H. 1968. Climate and agriculture: An ecological survey. Aldine Publishing. Chicago.

8. Ekern, P. C. 1966. Evapotranspiration by bermudagrass sod, Cynodon dactylon L. Pers., in Hawaii. Agron. J. 58:587-590.

9. Getz, R. 1979. Florida daily temperature normals. Fla. Coop. Ext. Serv. Circular 464.

10. Jensen, M. E. (ed.) Consumptive use of water and irrigation requirements. Amer. Soc. Civil. Engineers. New York.

11. Kneebone, W. R. and I. L. Pepper. 1982. Consumptive water use by sub-irrigated turfgrasses under desert conditions. Agron. J. 74:419-423.

12. Lange, O. L., L. Kappen, and E. D. Schulze. 1976. Water and plant life: Problems and modern approaches. Springer-Verlag. Berlin.

13. McCloud, D. E. 1955. Water requirements of field crops in Florida as influenced by climate. Proc. Soil Sci. Soc. Fla. 15:165-172.

14. McCloud, D. E. 1970. Water requirements for turf. Proc. Fla. Turfgrass Mgt. Conf. 18:88-90.

15. Meider, H. and D. W. Sheriff. 1976. Plants and water. Blackie and Sons. Glascow, Scotland.

16. Monteith, J. L. (ed.) 1976. Vegetation and the atmosphere. Volume 2: Case studies. Academic Press. London.

17. National Oceanic and Atmospheric Administration. 1980. Climatological data annual summary, Florida. 84 (13) National Climatic Center. Asheville, NC.

18. Pair, C. H., W. W. Hinz, C. Reid, and K. R. Frost. 1975. Sprinkler irrigation. The Irrigation Association. Silver Spring, MD.

19. Penman, H. L. 1948. Natural evaporation from open water, bare soil, and grass. Proc. Royal Soc. Series A 193:120-145.

20. Rosenberg, N. J. 1969. Seasonal patterns in evapotranspiration by alfalfa in the central Great Plains. Agron. J. 61:879-886.

21. Rosenberg, N. J. 1974. Microclimate: The biological environment. John Wiley & Sons. New York.

22. Sarsfield, A. C. 1966. The A B Cs of lawn sprinkler systems. Irrigation Technical Services. Lafayette, CA.

23. Speir, W. H. 1962. Installation and operation of non-weighing lysimeters. Soil Crop Soc. Fla. 22 167-176.

24. Stewart, E. H., J. E. Browning, and E. O. Burt. 1969. Evapotranspiration as affected by plant density and water table depth. Trans. A.S.A.E. 12:646-647.

25. Stewart, E. H. and W. C. Mills. 1967. Effect of depth of water table and plant density on evapotranspiration rate in southern Florida. Trans. A.S.A.E. 10:746-747.

26. Thornthwaite, C. W. 1948. An approach toward a rational classification of climate. Geo. Rev. 38:55-94.

27. Tovey, R., J. S. Spencer, and D. C. Muckel. 1969. Turfgrass evapotranspiration. Agron. J. 61:863-867.

28. U.S.D.A. Soil Conservation Service. 1970. Irrigation water requirements. Engineering Div. Tech. Rel. 21 Rev. 2.

29. Van Bavel, C. H. M. 1961. Lysimetric measurement of evapotranspiration in eastern United States. Soil Sci. Soc.. Proc. 25:138-141.

30. Watkins, J. A. 1978. Turf irrigation manual. Telsco Industries. Dallas, TX.

31. Weaver, H. A. and J. C. Stevens. 1963. Relation of evaporation to potential evapotranspiration. Trans. A.S.A.E. 6:55-56.

Table 1.

Table 1. Mean monthly evapotranspiration rates from St. Augustine grass and bermudagrass sods as observed in research plots at Fort Lauderdale, Florida (24, 25)

Month	Water use (inches)	Month	Water use (inches)
January	2.02	July	4.81
February	2.51	August	4.79
March	3.35	September	3.85
April	4.21	October	3.42
May	5.21	November	2.50
June	4.25	December	1.92
		Total	42.84

Table 2.

Table 2. Fort Myers area turfgrass irrigation requirements based on long-term climatic records.

Month	Mean Monthly Temperature (¡F)	Mean Monthly Rainfall (inches)	Potential Evapotranspiration (inches)	Net Irrigation Requirement (inches)
JAN	63.5	1.64	2.61	1.65
FEB	64.7	2.03	2.56	1.38
MAR	68.5	3.06	3.66	1.86
APR	73.3	2.03	4.92	3.57
MAY	77.7	3.99	6.82	4.12
JUN	81.1	8.89	8.31	2.51
JUL	82.5	8.90	9.46	3.26
AUG	82.8	7.72	9.61	4.06
SEP	81.6	8.71	8.61	2.91
OCT	76.4	4.37	6.26	1.54
NOV	69.4	1.31	3.78	2.96
DEC	64.8	1.30	2.85	2.07
TOTAL		53.95	69.45	31.89
AVG.	73.9			

Table 3.

Table 3. Gainesville area turfgrass irrigation requirements based on long-term climatic records.

Month	Mean Monthly Temperature (¡F)	Mean Monthly Rainfall (inches)	Potential Evapotranspiration (inches)	Net Irrigation Requirements (inches)
JAN	57.0	2.84	1.68	0.18
FEB	58.6	3.70	1.69	none
MAR	63.6	4.26	2.63	0.38
APR	70.0	3.02	3.92	2.12
MAY	75.8	3.54	6.00	3.70
JUN	80.0	6.81	7.71	3.21
JUL	81.1	8.03	8.59	3.09
AUG	81.2	8.25	8.65	2.85
SEP	79.1	5.67	7.26	3.51
OCT	71.8	3.67	4.58	2.38
NOV	63.3	1.92	2.49	1.44
DEC	57.8	2.88	1.78	0.58
TOTAL		54.59	56.98	23.44
AVG.	69.9			

Table 4.

Table 4. Jacksonville area turfgrass irrigation requirements based on long-term climatic records.

Month	Mean Monthly Temperature (¡F)	Mean Monthly Rainfall (inches)	Potential Evapotranspiration (inches)	Net Irrigation Requirements (inches)
JAN	54.6	2.78	1.43	none
FEB	56.3	3.58	1.45	none
MAR	61.2	3.56	2.24	0.34
APR	68.1	3.07	3.45	1.70
MAY	74.3	3.22	5.43	3.34
JUN	79.2	6.27	7.32	3.22
JUL	81.0	7.35	8.53	3.23
AUG	81.0	7.89	8.53	3.53
SEP	78.2	7.83	6.84	1.94
OCT	70.5	4.54	4.19	1.59
NOV	61.2	1.79	2.16	1.16
DEC	55.4	2.59	1.51	none
TOTAL		54.47	53.08	20.05
AVG.	68.4			

Table 5.

Table 5. Miami area turfgrass irrigation requirements based on long-term climatic records.

Month	Mean Monthly Temperature (¡F)	Mean Monthly Rainfall (inches)	Potential Evapotranspiration (inches)	Net Irrigation Requirement (inches)
JAN	67.2	2.15	3.35	2.09
FEB	67.8	1.95	3.16	1.99
MAR	71.3	2.07	4.42	3.12
APR	75.0	3.60	5.50	3.24
MAY	78.0	6.12	6.97	3.05
JUN	81.0	9.00	8.26	2.69
JUL	82.3	6.91	9.32	4.32
AUG	82.9	6.72	9.71	4.75
SEP	81.7	8.74	8.66	2.74
OCT	77.8	8.18	6.87	1.13
NOV	72.2	2.72	4.55	2.85
DEC	68.3	1.64	3.61	2.61
TOTAL		59.80	74.38	34.58
AVG.	75.5			

Table 6.

Table 6. Orlando area turfgrass irrigation requirements based on long-term climatic records.

Month	Mean Monthly Temperature (¡F)	Mean Monthly Rainfall (inches)	Potential Evapotranspiration (inches)	Net Irrigation Requirement (inches)
JAN	60.4	2.28	2.12	0.85
FEB	61.8	2.95	2.10	0.55
MAR	66.3	3.46	3.16	1.26
APR	72.2	2.72	4.56	2.88
MAY	77.5	2.94	6.73	4.73
JUN	81.2	7.11	8.37	3.57
JUL	82.4	8.29	9.39	3.59
AUG	82.7	6.73	9.58	4.68
SEP	81.1	7.20	8.31	3.41
OCT	75.0	4.07	5.67	3.17
NOV	67.1	1.56	3.21	2.28
DEC	61.8	1.90	2.33	1.19
TOTAL		51.21	65.53	32.16
AVG.	72.5			

Table 7.

Table 7. Pensacola area turfgrass irrigation requirements based on long-term climatic records.

Month	Mean Monthly Temperature (¡F)	Mean Monthly Rainfall (inches)	Potential Evapotranspiration (inches)	Net Irrigation Requirement (inches)
JAN	52.1	4.37	1.12	none
FEB	54.8	4.69	1.31	none
MAR	59.9	6.31	2.05	none
APR	68.1	4.99	3.45	0.70
MAY	75.2	4.25	5.77	3.02
JUN	80.6	6.30	8.04	3.74
JUL	81.8	7.33	8.99	3.89
AUG	81.8	6.67	8.99	4.39
SEP	78.3	8.15	6.87	1.77
OCT	70.0	3.13	4.03	2.13
NOV	59.5	3.37	1.93	0.13
DEC	53.8	4.66	1.35	none
TOTAL		64.22	53.99	19.77
AVG.	68.0			

Table 8.

Table 8. Tallahassee area turfgrass irrigation requirements based on long-term climatic records.

Month	Mean Monthly Temperature (¡F)	Mean Monthly Rainfall (inches)	Potential Evapotranspiration (inches)	Net Irrigation Requirement (inches)
JAN	52.6	3.74	1.25	none
FEB	54.8	4.77	1.31	none
MAR	60.3	5.93	2.10	none
APR	67.9	4.07	3.39	1.09
MAY	74.8	4.04	5.58	3.28
JUN	80.0	6.62	7.71	3.21
JUL	81.1	8.92	8.59	2.59
AUG	81.1	6.89	8.59	3.79
SEP	78.1	6.64	6.78	2.58
OCT	69.3	2.93	3.88	2.13
NOV	58.9	2.81	1.85	0.35
DEC	53.2	4.22	1.30	none
TOTAL		61.58	52.33	19.02
AVG.	67.7			

Table 9.

Table 9. Tampa area turfgrass irrigation requirements based on long-term climatic records.

Month	Mean Monthly Temperature (¡F)	Mean Monthly Rainfall (inches)	Potential Evapotranspiration (inches)	Net Irrigation Requirement (inches)
JAN	60.4	2.33	2.12	0.82
FEB	61.8	2.86	2.10	0.57
MAR	66.0	3.89	3.09	0.99
APR	72.0	2.10	4.50	3.15
MAY	77.2	2.41	6.60	4.90
JUN	81.0	6.49	8.25	3.85
JUL	81.9	8.43	9.08	3.38
AUG	82.2	8.00	9.27	3.67
SEP	80.8	6.35	8.16	3.96
OCT	74.7	2.54	5.58	3.93
NOV	66.8	1.79	3.15	2.10
DEC	61.6	2.19	2.30	1.07
TOTAL		49.38	64.20	32.39
AVG.	72.2			

Table 10.

Table 10. West Palm Beach area turfgrass irrigation requirements based on long-term climatic records.

Month	Mean Monthly Temperature (¡F)	Mean Monthly Rainfall (inches)	Potential Evapotranspiration (inches)	Net Irrigation Requirement (inches)
JAN	65.5	2.60	2.99	1.49
FEB	66.1	2.60	2.81	1.34
MAR	69.8	3.32	4.00	1.95
APR	73.9	3.51	5.11	3.11
MAY	77.5	5.17	6.73	3.33
JUN	80.5	8.14	7.98	2.68
JUL	81.9	6.52	9.07	4.47
AUG	82.3	6.91	9.32	4.32
SEP	81.5	9.85	8.54	2.04
OCT	77.2	8.75	6.60	1.30
NOV	71.0	2.48	4.20	2.65
DEC	66.8	2.21	3.27	1.97
TOTAL		62.06	70.62	30.65
AVG.	74.5			

Table 11.

Table 11. Conversion factors for turfgrass irrigation.	
Gross Irrigation Requirements =	Net Irrigation Requirement Application Efficiency
1 Acre inch of water = 27,154 gallons	
1 Acre inch of water = 1.028 hectare-centimeter of water	
Liters = Gallons x 3.78	
Centimeters = Inches x 2.54	
Millimeters = Inches x 25.4	
°Celsius = (°Fahrenheit -32)/1.8	