TURFGRASS SELECTION AND MANAGEMENT TO ACHIEVE MAXIMUM WATER CONSERVATION

James B. Beard
Texas A and M University, College Station, TX

INTRODUCTION

Water conservation is receiving a great deal of attention in national and regional publications, and rightly so. A dimension of water usage that has been receiving particular attention involves water inputs into urban landscapes. One of the reasons for this is that it is a highly visible activity in comparison to many day-to-day aspects of water usage. Unfortunately, a considerable amount of misinformation, partly due to misunderstandings of terminology, has occurred in newspapers and weekly news magazines. Accordingly, it is appropriate to define the terminology that will be used in this paper and its implications.

Evapotranspiration (ET) is defined as the total amount of water transpired from plants and evaporated from associated soil surfaces (1,2). This is what actually is measured in experimental investigations. Another term commonly used is water use rate, which is defined as the total amount of water required for turfgrass growth plus the quantity lost by transpiration and evaporation from plant and soil surfaces, respectively. The water use rate in absolute terms is only slightly higher than the evapotranspiration rate. Consequently, there is a tendency to use these two terms interchangeably in non-scientific articles. Turfgrass evapotranspiration rates are quantitatively measured via the water balance method using minilysimeter techniques. Although at first it might appear to be a simple technique, it proves to be quite complex in terms of utilizing the proper methodology that ensures repeatable results.

Evapotranspiration rate and drought resistance tend to be used interchangeably by many. Actually, drought resistance encompasses entirely different physiological processes than evapotranspiration (1,2). Drought resistance is a general term utilized to encompass a range of mechanisms whereby plants withstand periods of dry weather. There are three primary components of drought resistance: (a) dehydration avoidance, which is the ability to remain green during the progression of drought stress; (b) dehydration tolerance, which is the ability to endure low tissue water deficits caused by drought; and (c) escape. A species may have excellent drought resistance, but also have a very high evapotranspiration rate when soil moisture is available. Unfortunately, many popular articles discuss water conserving plants that are only drought resistant. Typically, the suggestion is to plant these into landscapes in combination with drip irrigation systems. Those species with a high evapotranspiration rate, even thought they are drought resistant, would in no way behave as water conserving plants. Thus, it is very important for both authors and readers to distinguish between evapotranspiration rate and drought resistance characteristics of individual species when addressing the issue of water conservation in landscapes.

TURFGRASS SPECIES - GENOTYPE DIVERSITY IN EVAPOTRANSPIRATION RATES

Detailed investigations of evapotranspiration rates involving inter- and intraspecies characterizations (2,3,5,6), plus plant morphological parameters involved in the mechanistic control of evapotranspiration have been pursued for the past twelve years as a major research thrust of this project. The interspecies characterization of ET rates initially involved assessment of the maximum ET rates under high evaporative demand and nonlimiting moisture (3,4,6). Subsequently, intraspecies characterizations of the major warm-season turfgrass species has been underway at Texas A&M University in College Station. The findings from a standardized series of studies are summarized in Table 1, along with the results for three major cool-season turfgrasses assessed at the University of Nebraska under the leadership of Dr. R. C. Shearman (7,8,9).

These investigations were selected for the summary table because they were conducted under representative summer, field, cultural conditions, with one exception, and under nonlimiting soil moisture status. The latter situation is required to eliminate differential root effects so the actual evapotranspiration differentials among genotypes can be delineated. The genotypes within each species are representative of the major cultivars now in use in North America. Note that the Texas and Nebraska locations would impose a higher midsummer evaporative demand on a warm-season and cool-season turfgrass species, respectively, than would be the case if the same turfgrass species and cultivars were grown in more northerly locations in North America.

Among the seven species compared, the bermudagrass genotype grouping included cultivars with the lowest ET rate means, followed by zoysiagrass and Kentucky bluegrass. Ranking intermediate were centipedegrass and St. Augustine grass. Tall fescue and perennial ryegrass were the highest in both the minimum and maximum genotype ET rate means. These data emphasis that when selecting water conserving turfgrasses in terms of low evapotranspiration rates it is important to specify the cultivar as well as the turfgrass species. Note in terms of actual rates, the evapotranspiration level would be considerably lower during the spring and fall growing seasons as well as during periods when the turfgrasses would be under partial water stress (6). The ET rate could easily be lower by 50% over a period of time under these conditions of modest evaporative demand and/or minimal irrigation.

In terms of genetic diversity in evapotranspiration rates, the bermudagrasses exhibited the greatest range, but also encompassed the largest number of cultivars. Kentucky bluegrass ranked second. These two species have received greater emphasis from the breeding standpoint on a long term basis than most other species. In contrast, centipedegrass and St. Augustinegrass had a very narrow range in ET rates. This may represent a lack of emphasis on the part of turfgrass breeders in selecting for low ET rate genotypes, plus very minimal overall breeding emphasis on these two species over the years.

Actually, there has been a void in developing water conserving turfgrasses across most turfgrass species. This need must receive much more attention by turfgrass geneticists in the future. It would be anticipated that if a comparable degree of emphasis was placed on this characteristic as has been placed on certain dimensions of turf density, texture, color, and disease resistance, considerable improvement may be possible in terms of reduced ET rates of turfgrasses.

DISCUSSION

A primary plant parameter affecting evapotranspiration rates across a broad range of grasses and dicotyledonous species is leaf area. In the case of turfgrasses, as the nitrogen fertility level or cutting height is increased there is a corresponding increase in leaf area and associated evapotranspiration rate. Ongoing research emphasizes that perennial grasses are relatively low water users. Statements declaring lawns and turfgrasses as high water consumers are misdirected in many cases. Actually, the major grasslands of the world tend to be located in relatively dry, semiarid climatic regions. The main problem involves improper irrigation practices. It is the human element in terms of improper irrigation practices that results in the so-called high water use on turfed landscape areas. Most of this wasted water is not even consumed by plants, but is lost directly as runoff.

Research findings emphasize that a range of turfgrass species and cultivars are available which are extremely low water users. In a 1990 Texas Agricultural Experiment Station Progress Report entitled "Comparative Dehydration Avoidances and Drought Resistances Among Major Warm-season Turfgrass Species and Cultivars" five turfgrass genotypes sustained a green, quality turf for an extended period of 158 days of drought stress in a high sand root zone, in which less than 3 inches (70 mm) of rainfall occurred in the entire five-month period, with most of that rainfall occurring in the first month. The five turfgrass genotypes were Ormond and NuMex Sahara bermudagrasses, Floratam and Floralawn St. Augustinegrasses, and Adalyd seashore paspalum. Certainly these are not high water users. In fact, most of the bermudagrass cultivars performed very well as water conserving landscape materials, including Ormond, NuMex Sahara, Texturf 10, Midway, Santa Ana, and Tifway.

These results show that quality landscapes involving turfgrasses can be used that sustain a high standard of water conservation. The key problem and need is to educate and motivate individuals involved in decisions concerning landscape irrigation to follow the proper watering techniques, which are actually very simple and less time consuming.

Follow Proper Turf Irrigation Practices:

The amount of supplemental irrigation water required for a given perennial turfgrass depends on: (a) the specific turfgrass species and cultivar, (b) environmental and cultural factors influencing the shoot evapotranspiration rate, (c) the water adsorption capability of the root system, (d) an efficient, effective irrigation system, and (e) the proper irrigation practices.

It is best to irrigate infrequently and deeply to the extent of the root system. At any one irrigation, apply water at a rate and duration that can be accepted into the soil. Stop irrigation before standing water appears on the surface.

- Apply irrigation water at a rate that does not exceed the soil infiltration and percolation rates.
- The total amount of water applied at any one irrigation should not result in soil water saturation and waterlogging.
- Schedule diurnal irrigations when temperatures are lowest to reduce evaporative loss; this is typically at dawn.
- Schedule diurnal irrigations when winds are lowest to achieve more uniform water distribution; this is typically at dawn.

A Drought Survival Strategy for Non-irrigated Turf:

Drought develops as a result of an extended period without precipitation, combined with the lack of an irrigation capacity and a high evapotranspiration rate. The severity of soil drought is affected by the duration without rain, the evaporative power of the air, and the water retention characteristics of the soil. Droughts are most likely to occur during the midsummer period, although the actual timing of occurrence and frequency are not predictable. There are a number of options available to prepare a turf for drought stress.

- Selection of drought resistance species and cultivars.
- Optimize turfgrass drought tolerance via cultural practices.
- Maximize rainfall effectiveness via water harvesting.
- Maximize water adsorption by roots.

Agricultural Practices to Enhance Survival of Turfs:

- Raise mowing height.
- Modest nitrogen nutritional level.
- Adequate potassium and iron nutritional levels.
- Turf cultivation by coring or slicing to 3-4 inch (75-100m) depth.
- Control any thatch.
- Maintain soil reaction near neutral.

There are certain adversary groups that have been active in promoting the reduction of turfgrass areas within urban landscapes and the replacement of the areas with trees and shrubs as a means of water conservation. Statements have been made such as "all turfgrasses are higher water users than trees and shrubs." There is no published scientific data available to support this statement. Actually, the major grasslands of the world are located in the semi-arid regions, whereas the major forests of the world are located in the higher rainfall areas. Just what is our current state of knowledge backed by sound scientific data concerning these issues of proper plant use for water conservation within the urban landscape.

- Very few of the many hundreds of tree and shrub species available have actually been quantitatively assessed for their water use rates.
- In contrast, a major portion of the turfgrass species have been assessed for water use rates.
- The few comparative water use studies that are available indicate that trees and shrubs are higher water users than turfgrasses, especially when soil moisture is available. This is based on the sound scientific premise that the rate of water use generally increases with leaf area.
- Much confusion has arisen from the "low water use plant lists." It has been incorrectly assumed that those plants capable of surviving in arid regions are in fact low water users. However, the physiological mechanisms controlling the water use rate and drought resistance are entirely different and are in no way directly correlated across plant species.
- For non-irrigated sites, detailed studies have been conducted on drought resistance and dehydration avoidance of many turfgrass species and cultivars. Results have shown that a number of turfgrass cultivars can survive 158 days in a sand root zone without irrigation under the hot summer conditions in College Station, Texas.
- Detailed studies of drought resistance among tree and shrub species are lacking.
- It should be recognized that when turfed areas are irrigated the adjacent tree and shrubs are also being irrigated as a result of the multitude of shallow roots that concentrate under the irrigated area.
- There are numerous turfgrasses capable of ceasing growth, entering dormancy, and turning brown during summer drought stress; that readily recover once rainfall occurs. Many assume that turfgrasses must be green throughout the summer season. However, many trees drop their leaves during drought stress, or during the winter period, with only brown bark remaining. What then is wrong with a tan to golden brown turf during droughts, if one chooses not to irrigate?
- There is no valid basis for water conservation legislation requiring the extensive use of trees and shrubs, in lieu of turfed areas. Rather the sound strategy based on good science is the use of appropriate low water use turfgrasses, trees, and shrubs for moderate to low irrigated landscapes and to select appropriate drought resistant turfgrasses, trees, and shrubs for nonirrigated areas.
- In most situations it is man who wastes water through improper irrigation practices and landscape designs rather than any one group of landscape plantings.

SUMMARY OF THE BEST LOW WATER USE RATE CULTIVARS*
OF THREE COOL-SEASON TURFGRASSES UNDER IRRIGATED CONDITIONS

Kentucky Bluegrasses (Poa pratensis)	Perennial Ryegrasses (Lolium perenne)	Tall Fescues (Festuca arundinacea)
Adelphi	Prelude	Shortstop
Newport	Blazer	Silverado
Baron	Citation	Murietta
Cheri	Manhattan II	Olympic
Park	Palmer	Mesa
Touchdown		Monarch
Parade		Mustang
Bensun		Trailblazer
		Rebel
		Apache

(J.B. Beard)

* Are readily available commercially.
Rankings in order within a column, with lowest at the to

SUMMARY OF THE BEST DROUGHT RESISTANT CULTIVARS
OF FOUR COOL-SEASON TURFGRASSES UNDER UNIRRIGATED CONDITIONS

Kentucky Bluegrasses (Poa pratensis)	Perennial Ryegrasses (Lolium Perenne)	Fine Leafed Fescues (Festuca rubra and longifolia)	Tall Fescues (Festuca arundinacea)
Majestic	Citation	Aurora	Kentucky 31
Merion	Yorktown	Jamestown	Murietta
Bristol	Saturn	Biljart	Olympia
America	Accolade	Scaldis	Monarch
Wabash	Omega	Tournament	Chesapeake
Kenblue	Charger	Waldorf	
Challenger		Waldena	
Baron		Shademaster	
Sydsport		Shadow	
Nugget			

(J. B. Beard)

*Are readily available commercially.
Rankings in order within a column, with best at the top.

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REFERENCES

1. Beard, J.B. 1973. Turfgrass: Science and Culture. Prentice-Hall, Inc. Englewood Cliffs, NJ 658 pp.

2. Beard, J.B. 1985. An assessment of water use by turfgrasses. In V.A. Gibeault and S.T. Cockerham (ed.) Turfgrass Water Conservation, Univ. Calif. Div. Agric. Nat. Resources Pub. 21405. 155 pp.

3. Beard J.B. 1989. Turfgrass water stress: drought resistance components, physiological mechanisms and species-genotype diversity. Proc. International Turfgrass Research Conf. Japan. 6:23-28.

4. Johns, D., J.B. Beard, and C.H.M. vanBavel. 1983. Resistance to evapotranspiration from a St. Augustine grass turf canopy. Agron. J. 75(3):419-422.

5. Kim, K.S., and J.B. Beard. 1988. Comparative evapotranspiration rates and associated plant morphological characteristics. Crop Sci. 28(2):328-331.

6. Kim, K.S., J.B. Beard, L.L. Mith, and M. Ganz. 1983. Comparative evapotranspiration rates of thirteen turfgrasses grown under both nonlimiting soil moisture and progressive water stress conditions. Texas Turfgrass Research - 1983. Texas Agaric. Exp. Stn. Consold. Prog. Rep. 4156:62-64.

7. Kopec, D.M., R.C. Shearman, and T.P. Riordan. 1988. Evapotranspiration of tall fescue turf. Hort Sci. 23:300-301.

8. Shearman, R.C. 1986. Kentucky bluegrass cultivar evapotranspiration rates. Hort Sci. 21(3):455-457.

9. Shearman, R.C. 1989. Perennial ryegrass cultivar evapotranspiration rates. Hort Sci. 24:767-769.