Turfgrass Selection

Comparing Three Turfgrasses for Minimum Irrigation Requirements, Drought Resistance and Long-Term Performance

By Y.L. Qian and M.C. Engelke

Drought is a regular environmental stress that causes the decline and loss of turfgrass. Consequently, irrigation is required in most areas of the United States to maintain desirable turfgrass quality throughout the growing season. The selection of appropriate turfgrasses can greatly assist water conservation efforts during future droughts.

Even though water is considered a precious and limited resource, there are many situations where water is excessively applied without regard to plant needs. Excessive irrigation, in addition to increasing the potential for leaching and surface runoff of pesticides and fertilizers, might also cause detrimental effects to turf, such as weakening the turf to be more prone to pest attacks (Colbaugh and Elmore, 1985).

Little is known about the response of turfgrass to excessive irrigation. More information is needed on how each turfgrass performs under various irrigation regimes.

Studies clearly indicate that turfgrasses differ in their performance during drought events. Researchers have put significant effort into developing and evaluating turf species that have good drought resistance (Carrow, 1995 and 1996a; Gibeault et al., 1985; Qian et al., 1997). However, considerable variability in rankings of relative drought resistance has been reported. Carrow (1996a) suggested that variations in the rankings of drought resistance might relate to regional climate conditions, assessment method and duration of drought events.

The authors devised a study using the line source sprinkler irrigation system (LSIS). The system, as described by Hanks et al. (1976), generates uniform irrigation gradients and allows determination of turfgrass drought resistance and water requirements in situ (White et al., 1993). It further facilitates the evaluation of turf persistence under continuous moisture gradients. The study was conducted at the Texas A&M University, Dallas Research Center, on a Houston clay soil.

LSIS was used to evaluate three major turfgrasses (bermudagrass, tall fescue and zoysiagrass) in northern Texas to:

- determine the minimum irrigation requirements and relative drought resistance; and
- evaluate the long term effects of irrigation levels on turf persistence and weed invasion.

Previous drought studies were evaluated. A greenhouse study in 1990 with five selected grasses (Sifers et al.) indicated the relative drought resistance was:

bermudagrass = zoysiagrass > tall fescue

A field study in Georgia (Carrow, 1996a) ranked the grasses:

Tifway bermudagrass > Rebel II tall fescue > Meyer zoysiagrass

In a Kansas, the relative drought resistance of the turfgrasses was:

Midlawn bermudagrass = Mustang tall fescue > Meyer zoysiagrass

Top Northern Texas Turfgrasses

Bermudagrass and tall fescue are the most commonly used turfgrass species in northern Texas. The use of zoysiagrass has increased during recent years due to its low maintenance requirements. Additional long-term field evaluation was needed to select drought resistant and water-saving grasses and to recommend better irrigation management practices.

Line Source Sprinkler Irrigation System

The LSIS consists of a single row of in-ground sprinkler heads located in the middle of the study area. The Thompson rotary pop-up, gear-drive sprinklers were spaced six meters apart, approximately one third of the maximum throw of each head. This sprinkler arrangement was designed to generate a perpendicular irrigation gradient (i.e., decreasing irrigation volumes with increasing distance from the irrigation line source (Hanks et al., 1976)).

Two warm-season grasses (Tifway bermudagrass and Meyer zoysiagrass) and one cool-season grass (Rebel II tall fescue) were solid-sodded in July 1992 into four 7 x 20 meter plots arranged perpendicular to the center irrigation line. During establishment, all grasses were irrigated the same, without the gradient.

During May 1993 to October 1996, irrigation was applied every three days at a rate of 120 percent of the Pan evaporation (Ep) for those three days. With the gradient, the 120 percent Ep kept the soil nearest the line source near field capacity. As distance from the center line increased, turf received less and less supplemental irrigation. The portion of the plot furthest from the center line received no supplemental irrigation. Irrigation occurred between 5 p.m. and 7 p.m. when winds tend to be calm. Rain gauges were positioned at 1.5 m increments from the irrigation line source.

Tall fescue was mowed weekly at 5.1 cm whereas bermudagrass and zoysiagrass were mowed at 2.5 cm with clippings removed. Nitrogen was applied at rates and times based on the growing seasons and the requirements of each of the grasses. Bermudagrass received 245 kg N/ha/yr, whereas zoysiagrass received 148 kg N/ha/yr, applied between May and August. Tall fescue received 245 kg N/ha/yr in February, March, May, September and November. Since one of our objectives was to assess the irrigation effects on disease and weed incidence, no herbicides or fungicides were applied throughout the study.

Excessive irrigation, in addition to increasing the potential for leaching and surface runoff of pesticides and fertilizers, might also cause detrimental effects and weaken turf.

Water Distribution and Turf Performance

To assess the minimum water requirements and relative drought resistance of the selected turfgrasses, the distance between the central irrigation line and the position where the turf could not maintain acceptable quality due to drought stress was determined during summer drought periods. We calculated the minimum water requirement as a proportion of the Pan evaporation (percent Ep) for each turfgrass on each evaluation date. Within each plot, three subplots were selected along the irrigation gradient to represent three irrigation regimes (high, medium and low). The amount of water received for these three irrigation regimes was approximately equal to 115, 55 and 10 percent Ep.

Turf performance, including turf quality, density, turf ground coverage, spring green-up and weed invasion, were evaluated at these three locations along the gradient. Turf quality was evaluated monthly during growing seasons on a 1 to 9 scale, where 6 was the minimum acceptable turf quality and 9 was the best. Turf density was likewise rated on a 1 to 9 scale where 9 was the best. Turf ground coverage was rated as percent area covered by living turf; turf ground coverage at the end of the study was considered an indicator of turf persistence under different irrigation regimes. Weed invasion was rated as percent area covered with weeds.

Weather permitting, clippings were harvested twice a month during the growing season from each irrigation level.

Minimum Water Requirements and Relative Drought Resistance

Following the initiation of LSIS on May 1993, significant differences among turfgrasses treatments appeared in July, indicating that stress gradients had been established. Analysis of the minimum irrigation required to maintain acceptable quality revealed that the dates of evaluation greatly influenced the effect of drought. (See Table 1.)

Grasses and their minimum irrigation requirements to prevent drought stress were:

Rebel II tall fescue, 49-67 percent Ep

Meyer zoysiagrass, 39-68 percent Ep

Tifway bermudagrass, 12-35 percent Ep

A range of water requirements is given for each grass because the amount of water required to prevent drought stress varied with the date of evaluation, suggesting the amount of water needed to maintain acceptable turf quality was affected by weather conditions, the duration of drought events and the length of growing seasons. However, to maintain acceptable turf quality throughout the growing seasons, it is safer to irrigate turfgrass with the amounts of water equivalent to the upper end of the range for each turfgrass.

Meyer and Gibeault (1986) reported that the water requirements for warm-season turfgrasses ranged from 43-63 percent Ep and 49-83 percent Ep for cool-season turfgrasses in California. In Georgia, Carrow (1995) reported that the average water requirements from May through October were 66, 80 and 78 percent Ep for Tifway bermudagrass, Meyer zoysiagrass and Rebel II tall fescue, respectively. Compared to water requirements reported for the same species in California and Georgia, our values for water requirements are lower. This may have been because:

1) the minimum water requirements required to maintain turf quality were reported in our study; or

2) turfgrasses in our study were maintained under low maintenance conditions, and the expectation for acceptable turf quality was lower compared to those reported.

The minimum irrigation requirements indicated that, under the conditions of this study, the ranking for relative drought resistance was:

Tifway bermudagrass >
Meyer zoysiagrass =
Rebel II tall fescue

This ranking generally agreed with the findings of Carrow (1996a). In contrast to a Kansas study in which deep rooted Mustang tall fescue exhibited better drought resistance than shallow rooted Meyer zoysiagrass (Qian et al., 1997), Rebel II tall fescue, a relatively deep rooted tall fescue cultivar (Carrow, 1996b), performed equal to

IRRIGATION REQUIREMENTS

Table 1. Irrigation requirements [% Pan evaporation (Ep)] of three golf turfgrasses under a line source irrigation system.

Grass	Irrigation requirements (% Ep) 7/6/93	8/4/94	9/7/95	8/8/96	11/7/96	Range
'Tifway' bermudagrass	21.4	11.9	20.1	35.0	31.7	12-35
'Meyer' zoysiagrass	67.5	64.0	38.5	52.0	45.7	39-68
'Rebel II' tall fescue	66.5	65.0	52.3	61.0	49.0	49-67

or slightly inferior to Meyer zoysiagrass in this study. It is likely that the higher summer temperature in Texas and the clay soil in our study site negated tall fescue's deep rooting potential to resist drought. However, Sifers et al. (1990) reported that bermudagrass and zoysiagrass had better drought tolerance than tall fescue. Their research was conducted in soil-filled containers that may have limited potential root development. Rooting ability is one of the most important components of drought resistance in turfgrass (Huang et al., 1997; Qian et al., 1997).

Turf Quality — Turf quality differed among irrigation regimes for each grass (Table 2). Turf quality of bermudagrass, zoysiagrass and tall fescue increased linearly as the amount of irrigation increased. All grasses had lower turf quality when irrigated at 10 percent Ep compared to areas irrigated at 55 percent or 115 percent Ep.

Tall fescue and zoysiagrass had denser turf canopies at 115 percent Ep (Table 2). Zoysiagrass and tall fescue had very poor density in areas receiving 10 percent Ep.

Clipping Yield — Irrigation level significantly influenced clipping dry weights for all grasses (Table 2). Turf clipping production decreased with decreasing irrigation. Weed encroachment in the zoysiagrass plot receiving 10 percent Ep prevented clipping collection.

Spring Green-Up — Irrigation level also significantly affected spring green-up (data not shown). Earlier spring green-up was noted in areas receiving 115 percent Ep for bermudagrass and zoysiagrass, and in areas receiving 55 percent Ep for tall fescue.

Quality was not improved for bermudagrass when watered at a rate above 55 percent Ep. Tall fescue and zoysiagrass had denser turf canopies at 115 percent Ep.

Turf Ground Cover — Tifway Bermudagrass had a relatively wider range of adaptation and exhibited decreased turf ground cover only at <18 percent Ep after four years of irrigation treatments.

Meyer zoysiagrass had highest ground coverage at 115 percent Ep and exhibited excellent persistence and superior performance in areas receiving >68 percent Ep, but deteriorated when subjected to <39 percent Ep. The turf ground coverage was only 11 percent after being irrigated with 10 percent Ep for three years. Prostrated spurge (*Chamaesyce humistrata* Engelm.) and spotted knapweed (*Centaurea maculosa* Lam.) severely invaded zoysiagrass plot irrigated at <39 percent Ep.

QUALITY, DENSITY AND CLIPPING YIELDS

Table 2. Mean visual quality, density and clipping yields of three golf turfgrasses under line source irrigation system during growing season between 1994-1996.

	Turf quality[z]			*Turf density*[z]			*Clipping yield* (g m-2d-1)[y]		
Grass	*115%Ep*	*55%Ep*	*<10%Ep*	*115%Ep*	*55%Ep*	*<10%Ep*	*115%Ep*	*55%Ep*	*<10%Ep*
Tifway bermudagrass	7.6A	7.3A	5.2	8.3	8.0	5.0	2.97	2.55	1.57
'Meyer' zoysiagrass	7.7	6.3	3.4	8.4	6.8B	2.0	1.91	1.75	—
'Rebel II' tall fescue	6.7	6.0	4.0	7.4	5.9	2.1	2.47	2.10	0.50

z Mean of monthly rating from May to October from 1993 to 1996. Turf quality and density were rated on a scale of 1 to 9, where 6 is the minimum acceptable quality and 9 is the optimal.

y Mean of 16 dates from 1994 to 1996.

Weed and Disease Invasion — Tall fescue had a relatively narrow range of adaptation. The drought stress caused severe thinning of tall fescue at deficit irrigation regimes. Tall fescue plots irrigated with >100 percent Ep exhibited a high percentage of bluegrass [Texas bluegrass (*Poa arachnifera* Torr.), Kentucky bluegrass (*Poa pratensis* L.) and annual bluegrass (*Poa annua* L.)] invasion. Due to the compatibility of *Poa* with tall fescue, turf quality and density were maintained at the high irrigation regime for tall fescue.

Bermudagrass had the best drought tolerance. Tall fescue had the highest irrigation requirement in northern Texas.

During the experimental period in 1996, dollar spot in bermudagrass, and leaf spot in tall fescue were observed. No diseases were detected in Meyer zoysiagrass. Enhanced dollar spot incidence was observed in Tifway bermudagrass plots watered at >80 percent Pan evaporation. Our results support the finding of Jiang et al. (1998) who reported that excessive irrigation enhanced dollar spot.

In conclusion, this study suggested that among the three grasses tested, Tifway Bermudagrass had the best drought tolerance, followed by Meyer zoysiagrass. Rebel II tall fescue had the highest irrigation requirement in northern Texas. Zoysiagrass and tall fescue lost turf coverage at 10 percent Ep.

Y.L. Qian, Department of Horticulture and Landscape Architecture, Colorado State University, Fort Collins, CO 80523-1173 and M.C. Engelke, Texas A&M Res. and Ext. Ctr., Texas A&M Univ. System, 17360 Coit Road, Dallas, TX 75252-6599.

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