Executive Summary, Fall 1994

Characterization of Water Use Requirements and Gas Exchange of Buffalograss Turf

Submitted by: Daniel C. Bowman

Since irrigation accounts for nearly half of urban water use, considerable savings could be realized by planting turfgrasses with low water requirements. Buffalograss may be the ideal species for both water savings and aesthetics, but water use data are scarce and one can only speculate on water requirements. This study is generating crop coefficients for buffalograss and identifies intraspecific water use differences among a diverse selection of genotypes.

A field project was installed at the UNR Valley Road Field Station to determine water use requirements of seventeen buffalograss genotypes representing a diverse genetic background. This project utilizes a line source water gradient in which buffalograss varieties are planted in strips down the gradient. Turf performance can be measured at any given irrigation amount, and minimum irrigation requirements are indicated by that point in the gradient beyond which the turf goes dormant or cannot survive.

Mini-lysimeters (15 cm diameter, 30 cm depth and each with a drain hole and removable plug to stop drainage) were planted, four per genotype, and established in the greenhouse. Cores for the lysimeters were drilled in each plot 2 meters from the main irrigation line. These will be used to determine ET gravimetrically under non-limiting conditions. These lysimeters were used in a greenhouse experiment to determine intraspecific differences in water use rates. The results indicate that significant differences do exist in water use between buffalograss varieties, but the differences are relatively small. However, average water use rates are quite low (approximately half) in comparison to a similar experiment with tall fescue.

The line source gradient was established in July, 1994, with irrigation scheduled based on ET (modified Penman) as determined with weather station data. Date on ET under non-limiting conditions, turf quality, canopy temperature, soil moisture, minimum water requirements, and plant water status were collected during 1994. The data demonstrate significant differences between genotypes for water use (crop coefficients ranged from 0.76 to 1.02) and turf quality. Canopy temperatures were relatively unaffected by drought until the end of the experiment, and then only increased at the very outer edge of the plots. Over the course of this experiment (31 days), the point demarcating the minimum irrigation required to prevent total dormancy corresponded to approximately 10-20% ET. It is apparent from this first year's data that buffalograss can produce an acceptable turf with deficit irrigation of 50-60% ET, at least a relatively short period of time. The experimental period will be extended to at least 10 weeks in 1995 to more severely stress the turf.

Progress Report, November, 1994

Characterization of Water Use Requirements and Gas Exchange of Buffalograss Turf

Submitted by: Daniel C. Bowman

This project is designed to determine water use requirements of seventeen buffalograss genotypes representing a diverse genetic background. A line source water gradient provides a continuous range of irrigation volumes from a value set at potential ET to essentially zero. By planting the buffalograss varieties in strips down the gradient (perpendicular to the irrigation line), turf performance can be measured at any given irrigation amount. See Figure 1 for a plot map.

An initial study was conducted in the greenhouse in May, 1994 to establish intra-specific differences in water use rates. Data were submitted in May describing this work, and it will not be repeated here. It should be noted, however, that the experiment was conducted a third time with very similar results to the first two trials.

The line source gradient was instituted on July 12 by adjusting the two outside irrigation lines to water only the tall fescue border. Irrigation was scheduled twice each week to apply 100% ET at the irrigation line as determined from weather station and the modified Penman equation. Mini-lysimeters positioned close to the irrigation line in each plot were used to determine ET gravimetrically under non-limiting conditions. Lysimeters were covered with fitted caps during irrigation of the plots to exclude water and reduce variability. Each was irrigated manually to a volumetric water content of 30% and the weight recorded to an accuracy of 1 gram. Water loss was determined by weighing the pots three or four days later, corresponding to the next scheduled irrigation. Actual amount and distribution of each irrigation was determined with catch cans spaced at 1 m intervals across the gradient (Fig. 2). Each subsequent irrigation event was adjusted to correct for previous excess or deficit irrigation. Over the experimental period, applied irrigation closely matched target values (Fig. 3a). The gradient was discontinued on August 18 by resetting the outside lines to irrigate the buffalograss. The plots were mowed weekly with clippings removed.

Turfgrass canopy temperatures were measured weekly at 1 m intervals along each plot using a hand-held infrared thermometer. Soil moisture was measured by Time Domain Reflectrometry (TDR) using 30 cm triple wire probes. Probes were installed in replicate plots of only two genotypes due to financial limitations. Three probes were positioned in each plot of Nebraska 315 and Tetraploid 1-14 at locations in the gradient corresponding to 100%, 70% and 40% of maximum irrigation. Pre-dawn leaf water potential was determined by thermocouple psychrometry on the same two genotypes with tissue collected adjacent to each TDR probe. Turf quality was rated visually for all plots on August 17 at points in the gradient representing 100% and 40% of potential ET. Finally, each plot was visually evaluated to determine the transition point between dormant and non-dormant turf, and the distance to the transition line was measured. This transition was assumed to represent the minimum amount of irrigation required for growth in the short term, and survival in the long term. Data were analyzed by ANOVA and means separated by LSD when significant differences existed.

Results

Evapotranspiration was determined for turf under non-limiting soil moisture, using in-ground lysimeters. Particular care was taken to keep the turf canopy clipped at a line parallel to the vertical edge of the lysimeters so that ET could be expressed on a soil area basis. Data were collected every three to four days, and significant differences in ET between genotypes were found for each measurement. For brevity, however, only data for cumulative ET are presented (Table 1, Fig. 3b). Total ET ranged from 21 to 28 cm, corresponding to crop coefficients (Kc's) of 0.76 to 1.02. Rankings were generally similar between dates. Hilight-912 and Plains were consistently among the highest water users, ranking in the top five for each of the nine sampling dates. Diploid 3-5 ranked in the top five for six of the nine dates. The three tetraploid genotypes, 1-14, 2-2 and Washoe, were consistently among the lowest water users, ranking in the bottom five for six, nine and seven of the sampling dates, respectively. Interestingly, of the five genotypes ranking lowest for total water use, four were tetraploids.

While there were relatively large differences in water use under non-limiting soil moisture, there was no significant difference in the distance along the gradient at which the turf entered dormancy (11.0 meters from the irrigation line). This distance corresponds to irrigation of 10-20% ET. Over the short period of this experiment, this amount represents the minimum to maintain growth, but not necessarily quality turf (see below). In this experiment, the transition line was determined by the integrated effects of deficit irrigation and soil moisture depletion. With a deep root system, buffalograss is able to avoid drought stress for an extended period by depleting the large reservoir of soil moisture. Over the longer term of several months to a season, the transition line might be interpreted as indicating the absolute minimum for turf survival. If the experiment had been conducted over a longer period, it is speculated that the transition line would adjust to a point closer to the central irrigation line.

Turfgrass quality was rated at the end of the experiment (Table 2). Several genotypes produced a turf of near-acceptable quality (Neb. 315, Neb. 609, Tetraploid 2-2, Washoe) while others, mainly seeded or vegetative hexaploids, were of low quality (Plains, Topgun, Guymon 2), with Diploid 3-5 being an exception. There was a negative but not significant correlation ($P=0.067$) between rankings for turf quality and water use. Of those with nearly acceptable quality, Tetraploid 2-2 and Washoe were also among the lowest water users. Turf quality was significantly reduced ($P < 0.001$) at 40% ET, with the relative rankings being very similar between 100% and 40% ET (Spearman's Rank correlation coefficient = 0.75, $P = 0.001$). Turf quality was not evaluated at 70% ET because it was visually apparent that even slight reductions in quality due to drought stress were much further out on the gradient.

Canopy temperature was measured at 1300 hr once each week at 1 meter intervals for all plots. Air temperature averaged approximately 34^{o} C and relative humidity was typically 8-15%. For simplicity, only data for two high and two low water users are presented. There was no apparent increase in canopy temperature with decreasing irrigation after two weeks (July 25) for any of the genotypes (Fig. 4), with an average canopy temperature being nearly the same as air temperature. By the end of the experiment (August 18), canopy temperature increased relatively sharply approximately 10 meters from the irrigation line, indicative of drought stress and corresponding to roughly 25% ET. These data suggest that root zone soil moisture was adequate for at least two weeks during deficit irrigation.

Pre-dawn leaf water potential was determined twice during the experiment. However, the data was widely scattered and no significant differences were found between positions on the gradient. This may be the result of heavy dew that collected on the leaf blades during the night. Although leaves were thoroughly blotted dry prior to placement in the thermocouple chambers, the possible effects of a coating of free water on leaf water potential must be considered.

Changes in soil moisture were monitored by time domain reflectrometry in the Neb. 315 and Tetraploid 1-14 plots (Fig. 5). These plots were chosen based on the preliminary data from the greenhouse experiments as representative of high and low water using genotypes. Soil moisture was very similar both between genotypes, and also between the 100% and 70% ET positions, where it averaged approximately 30% during the 31 day experimental period. At the 40% ET position, soil moisture declined steadily to 15% and 20% for Neb. 315 and Tetraploid 1-14, respectively. Oscillations in the curves are due to irrigation events. These data are useful in interpreting both the canopy temperature and turf quality data. It is apparent that deficit irrigation at 70% ET was not severe enough, at least over the period examined, to impose drought stress on the turf. By comparison, 40% ET resulted in considerable soil moisture depletion and drought stress, based on quality ratings. In all cases, however, turf was still growing, albeit at a reduced rate, at 40% ET.

Collectively, these data define water requirements for buffalograss both at the species and genotype levels. It is planned to continue this project through next season, with the following changes: 1) a longer period (10 weeks) of gradient irrigation will be used to more severely stress the turf, 2) TDR probes will be installed plots of Hilight 912 (high water user) and Tetraploid 2-2 (low water user), 3) an additional set of TDR probes will be installed to a depth of 60 cm, allowing a more detailed analysis of soil moisture depletion, and 4) leaf water potential will be determined at mid-day to avoid confounding the data with the effects of dew.

Table 1. Total evapotranspiration measured over a 31 day period during summer, 1994, and crop coefficients for buffalograss selections. Values are means of four replicates.

Selection/Cultivar	Evapotranspiration (cm)	Crop Coefficient	
Hilight 912	27.9	1.02	a*
Plains	27.2	1.00	ab
Diploid 3-5	26.0	0.95	a-c
Kennemer	25.2	0.92	b-d
Prairie	24.7	0.90	c-e
Topgun	24.7	0.90	c-f
Guymon 1	24.3	0.89	c-g
Neb. 609	24.3	0.88	c-g
Neb. 315	24.3	0.88	c-g
Guymon 2	24.3	0.88	c-g
Hilight 15	23.8	0.87	c-g
Guymon 6	23.7	0.86	c-g
Tetra. 2-5	23.3	0.85	d-h
Diploid 2-7	22.5	0.82	e-h
Washoe	22.3	0.81	f-h
Tetra. 1-14	22.2	0.81	gh
Tetra. 2-2	21.0	0.76	h

*Values in a column followed by the same letter are not significantly different at the P=0.05 level.

Table 2. Quality ratings for buffalograss selections as a function of irrigation. Plots were rated on a scale of 1-9 (9 being highest) at locations in the irrigation gradient corresponding to 100% and 40% of potential evapotranspiration. Values are means of four replicates.

Selection/Cultivar	Rating (100% ET)	Selection/Cultivar	Rating (40% ET)
Neb. 609	6.5 a	Neb. 609	5.25 a
Neb. 315	6.25 a	Neb. 315	5.0 a
Tetra. 2-2	6.25 a	Washoe	5.0 a
Washoe	6.0 ab	Hilight 15	5.0 a
Hilight 15	6.0 ab	Kennemer	4.25 b
Tetra. 2-5	5.75 a-c	Tetra. 1-14	4.0 bc
Guymon 1	5.25 b-d	Guymon 6	3.75 b-d
Tetra. 1-14	5.25 b-d	Prairie	3.75 b-d
Hilight 912	5.25 b-d	Tetra. 2-2	3.75 b-d
Kennemer	5.0 c-e	Hilight 912	3.5 c-e
Guymon 6	5.0 c-e	Tetra. 2-5	3.5 c-e
Diploid 2-7	5.0 c-e	Diploid 3-5	3.5 c-e
Prairie	4.75 d-f	Guymon 1	3.25 d-f
Guymon 2	4.5 d-f	Guymon 2	3.25 d-f
Topgun	4.25 e-g	Diploid 2-7	3.0 e-g
Plains	4.0 fg	Topgun	2.75 fg
Diploid 3-5	3.5 g	Plains	2.5 g

*Values in a column followed by the same letter are not significantly different at the P=0.05 level.

Figure 1. Plot map of buffalograss genotypes planted perpendicular to the central irrigation line.

Figure 2. Irrigation gradient as a function of distance from central irrigation line.

Figure 3. Comparison of actual applied vs. target irrigation during treatment period (top) and cumulative evapotranspiration for three high and three low water-using buffalograss genotypes (bottom).

Figure 4. Mean canopy temperatures as a function of distance from the central irrigation line for two high and two low water-using buffalograss genotypes. Sampling dates were July 25 (top) and August 18 (bottom).

Figure 5. Soil moisture (cm^3/cm^3) in the top 30 cm of soil as a function of time for two buffalograss genotypes. Measurements were made at positions in the irrigation gradient corresponding to 100%, 70% and 40% of ET.

Figure 1.

Northwest · Block 1 · Block 2 · Northeast
Southwest · Block 3 · Block 4 · Southeast

Plot (west to east)	Block 1	Block 2	Block 3	Block 4
1	Plains	Kennemer	Highlight 15	Guymon 6
2	T 1–14	Topgun	Guymon 6	Plains
3	Guymon 2	Washoe	T 2–5	Highlight 912
4	Neb.315	Prairie	Prairie	Highlight 15
5	Guymon 1	T 2–2	Guymon 2	Kennemer
6	Washoe	Neb. 609	Kennemer	T 1–14
7	Highlight 912	Guymon 1	Neb.315	T 2–2
8	Topgun	T 1–14	D 3–5	Neb.315
9	Kennemer	T 2–5	T 1–14	D 2–7
10	Guymon 6	Guymon 2	Plains	Topgun
11	T 2–5	Highlight 15	Topgun	Guymon 1
12	D 2–7	Neb.315	Washoe	Prairie
13	D 3–5	Guymon 6	Guymon 1	T 2–5
14	Prairie	D 2–7	Highlight 912	Neb. 609
15	T 2–2	Plains	D 2–7	D 3–5
16	Neb. 609	D 3–5	T 2–2	Washoe
17	Highlight 15	Highlight 912	Neb. 609	Guymon 2

Fig. 2

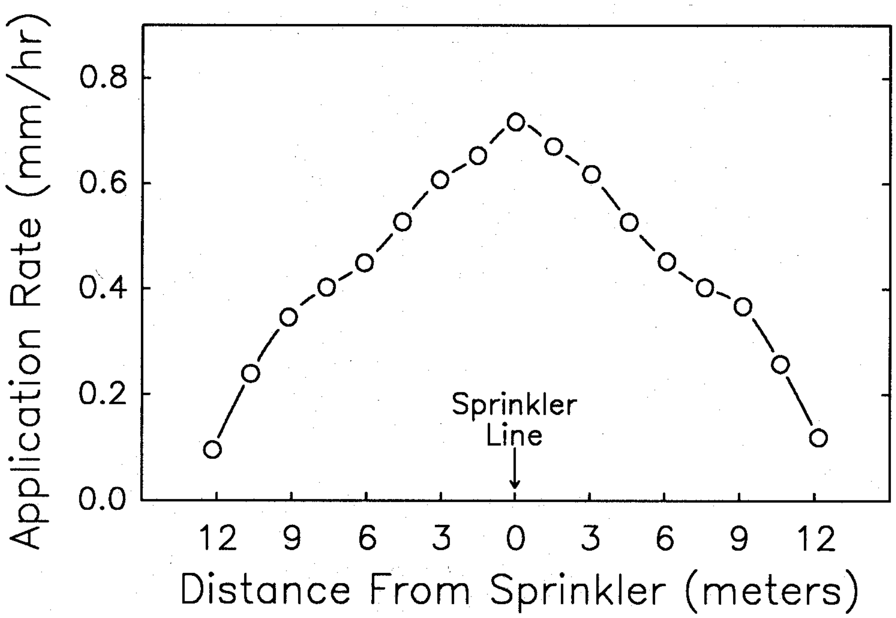

Application Rate (mm/hr)
0.8
0.6
0.4
0.2
0.0
Sprinkler Line
12 9 6 3 0 3 6 9 12
Distance From Sprinkler (meters)

Fig. 3a

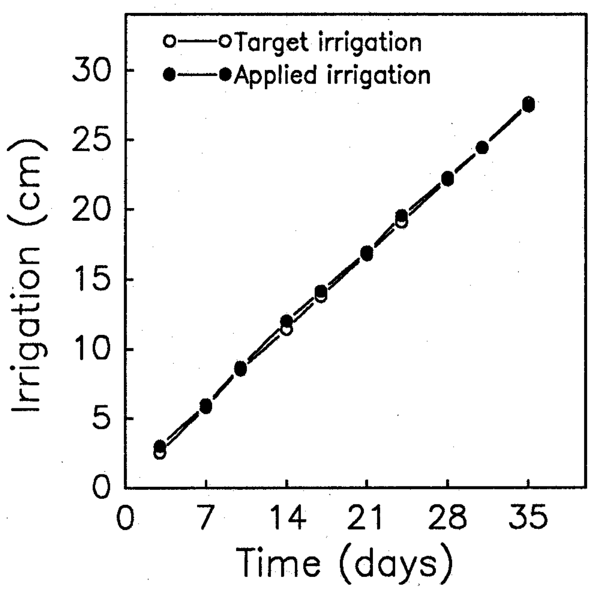

Target irrigation
Applied irrigation
Irrigation (cm)
0
5
10
15
20
25
30
0
7
14
21
28
35
Time (days)

Fig. 3b

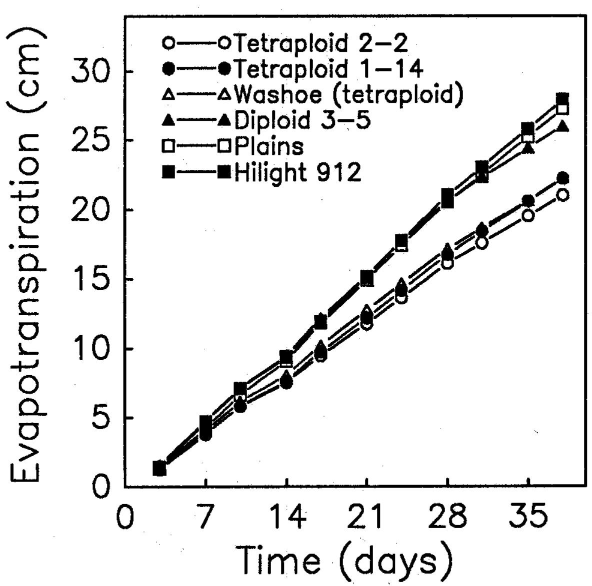
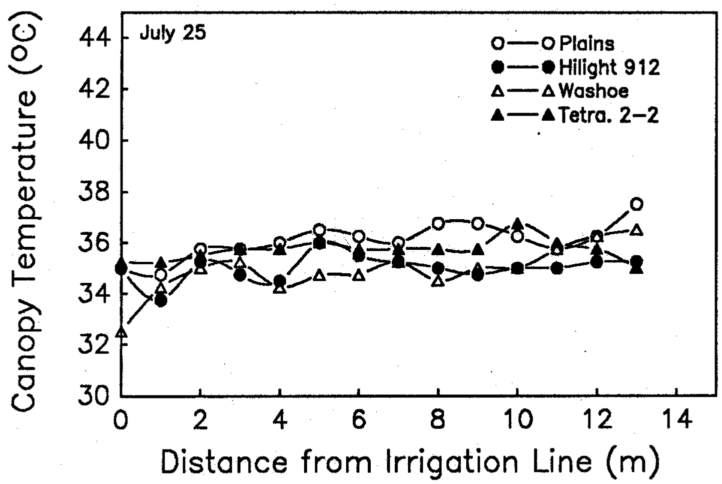
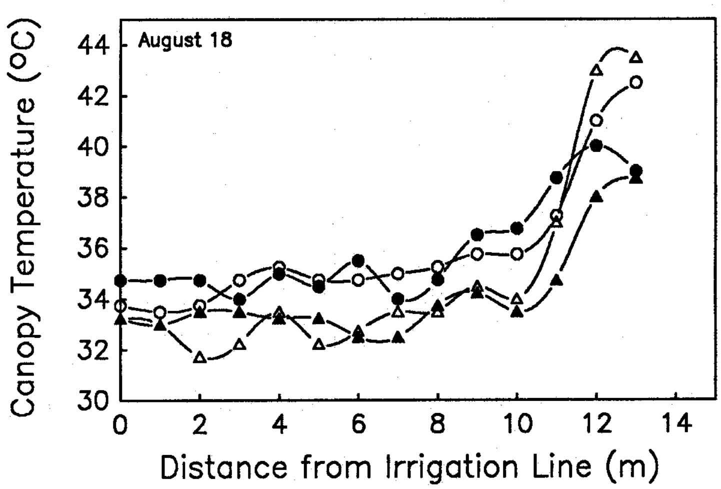

Tetraploid 2−2
Tetraploid 1−14
Washoe (tetraploid)
Diploid 3−5
Plains
Hilight 912
Evapotranspiration (cm)
0
5
10
15
20
25
30
0
7
14
21
28
35
Time (days)

Fig. 4

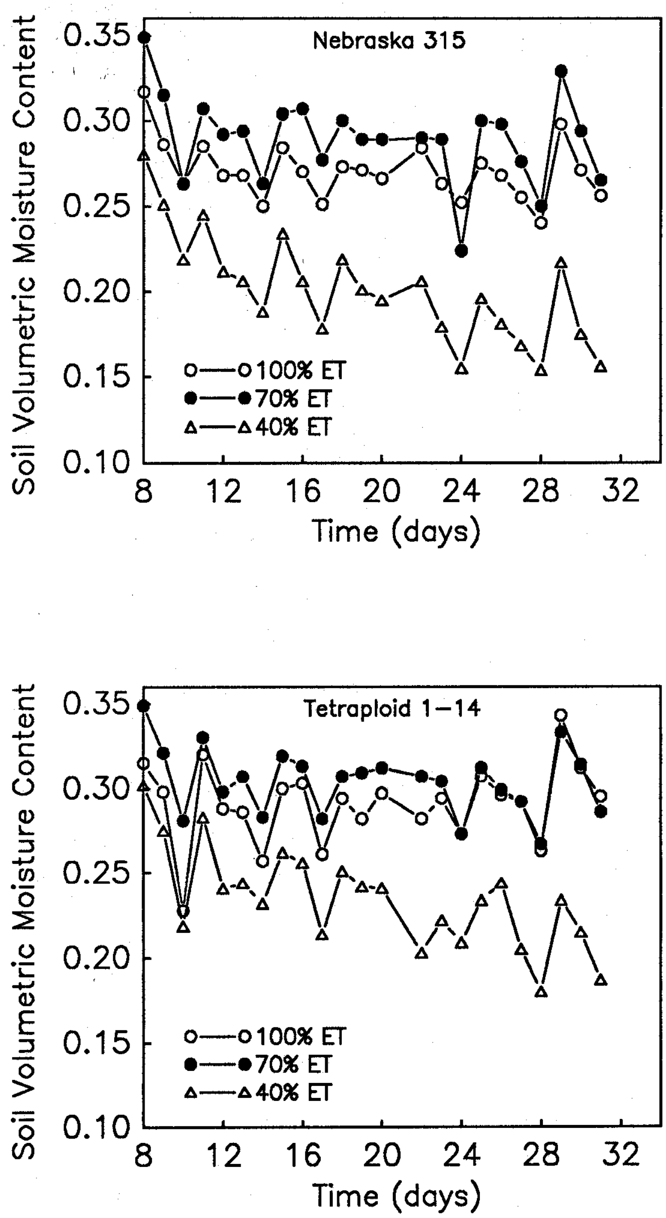


July 25
Plains
Hilight 912
Washoe
Tetra. 2-2
Canopy Temperature (°C)
44
42
40
38
36
34
32
30
0
2
4
6
8
10
12
14
Distance from Irrigation Line (m)



August 18
Canopy Temperature (°C)
44
42
40
38
36
34
32
30
0
2
4
6
8
10
12
14
Distance from Irrigation Line (m)

Fig. 5



Nebraska 315
Soil Volumetric Moisture Content
0.35
0.30
0.25
0.20
0.15
0.10
8
12
16
20
24
28
32
Time (days)
100% ET
70% ET
40% ET
Tetraploid 1–14
Soil Volumetric Moisture Content
0.35
0.30
0.25
0.20
0.15
0.10
8
12
16
20
24
28
32
Time (days)
100% ET
70% ET
40% ET