Tall Fescue Morphological Characteristics Associated with Evapotranspiration Rates and Clipping Yield

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I. Summary

The major objective of this study was to evaluate well-grown tall fescue cultivars for respective evapotranspiration rates (ET or water use rates) and their associated, above-ground morphological characteristics, such as clipping yield, leaf density, etc. Seven cultivars of tall fescue were seeded into black plastic pots (10-inch diameter x 12-inch deep), established for 7 months, and evaluated in the summer of 1994 for ET rates, clipping yields, leaf extension rates, and other leaf characteristics. The cultivars were evaluated under well-watered, field conditions in four, 7-day trials.

Data from this first-year study showed the following:

1. There were minimal differences in ET rates among the seven cultivars.

2. There were significant differences among the cultivars for important agronomic characteristics, such as clipping yield (46% difference between the highest and lowest cultivar) and leaf density (52% difference between highest and lowest cultivar).

3. ET rate was not significantly associated with any other measurement, while clipping yield was significantly (+) associated to leaf extension rate, and significantly (–) associated to leaf density.

4. RF 1**,** Shortcut (JC 12), and Tomahawk produced the lowest clipping yields and also had the highest combination of slow leaf extension rate and high leaf density.

II. Materials and Methods

Seven cultivars of tall fescue were seeded into lysimeters for 7 months, and then evaluated in the summer of 1994 for their ET rates, clipping yields, and above-ground morphological traits (Tables 1 to 6). The above-ground morphological diversity within this seven-cultivar collection was fairly representative of the morphological diversity observed within tall fescue cultivars utilized for turfgrass purposes.

Well-established turfgrass grown under a management program reflective of the production of high quality tall fescue was evaluated in this study (Tables 1 and 2).

ET rates were measured by the water-balance method in four separate trials (Tables 2, 3 and 4). Note that ET rates were measured when the tall fescue lysimeters were placed under field conditions, were well watered, and were in the last 3 days of a 7-day mowing cycle (Tables 3 and 4). Environmental conditions during the four trials were recorded by a CIMIS station located at the UCR Turfgrass Research Project (Table 5).

Clipping yields and leaf extension rates also were measured during each ET rate trial (Tables 4 and 6). Leaf density, length, and width were measured between the third and fourth ET rate trials (Tables 4 and 6). Visual turfgrass quality was measured during and after the study (Table 6).

III. Results and Discussion

a. Visual Turfgrass Quality and ET Rate

The major objective of this study was to evaluate well-grown tall fescues for ET rates and associated above-ground morphological characteristics. The turfs that were evaluated in this study were established from seed for 7 months, and the relatively high visual turfgrass quality ratings shown in Table 7 indicate in part the high quality management program that was maintained.

The differences among the seven cultivars for ET rate when evaluated under well-watered conditions was not significant (Table 8). However, it should be noted that a total of 22 cultivars were evaluated for ET rates, while only seven cultivars were evaluated for clipping yield and other morphological characteristics. The differences among the 22 cultivars in ET rates was significant, and the percent difference between cultivars with the highest and lowest ET rate was similar to previous research findings (Table 9).

b. Clipping Yield, Leaf Extension Rates, and Other Morphological Characteristics

Unlike the ET rate, there were significant differences among the seven cultivars for clipping yield (Table 10), leaf extension rate (Table 11), and leaf density, length, and width (Table 12). The percent difference between the cultivars was: clipping yield (46%); leaf extension rate (34%); leaf density (52%); leaf length (23%) and leaf width (31%).

c. ET Rate and Clipping Yield Correlated to Morphological Characteristics

ET rates were not correlated significantly to clipping yield, leaf extension rate, or any of the above-ground morphological characteristics (Table 13). Conversely, clipping yield was significantly (+) correlated to leaf extension rate, leaf length, and leaf width, and significantly (–) correlated to leaf density. [Note, a (+) correlation indicates that as one variable increases, the second variable increases also, or as one variable decreases, the second variable decreases also. A (–) correlation indicates that as one variable increases, the second variable decreases, or as one variable decreases, the second variable increases.]

-SUMMARY-

These data show that there are minimal differences among the seven tall fescue cultivars assessed in this study for ET rate when grown in 10-inch diameter x 12-inch deep lysimeters and maintained under well-watered, field conditions.

However, there were significant differences among the same cultivars for important agronomic characteristics, such as clipping yield (46% difference between the highest and lowest cultivar) and leaf density (52% difference between the highest and lowest cultivar).

ET rate, when evaluated under well-watered conditions, was not associated to clipping yield, leaf density, or any other morphological characteristics that were measured. However, there was a significant (+) association between clipping yield and leaf extension rate and a significant (–) association between clipping yield and leaf density.

From an applied field perspective, it is interesting that tall fescue cultivars with slow leaf extension rates and high leaf densities produced the lowest amount of clippings. Cultivars with a combined slow leaf extension rate and high leaf density included RF 1, Shortcut (JC 12), and Tomahawk. It should be noted that high visual turfgrass quality is normally associated with higher leaf densities and smaller leaves.

Some caution should be exercised when interpreting this report because data represent only one season, and turfs were grown in pots under well-watered conditions. This study represents an initial first step in studying tall fescue, water savings and morphological characteristics.

Table 1. Outline for tall fescue ET rate study.

Objective	To identify morphological characteristics of tall fescue cultivars associated with evapotranspiration rates when assessed under well-watered, field conditions.
Cultivars	Amigo, Bonsai, Falcon, Shortcut (JC 12), Monarch, RF 1, and Tomahawk.
Location	Glasshouse 30, Turf Field Laboratory for establishment; moved to field (12E, block 7) for ET rate measurements.
Growth assembly	Black plastic pots 25-cm (10-inch) diameter, 30-cm (12-inch) deep. Approximate volume: 14.7 L (0.55 ft^3). Bottom sealed with organdy cloth; pots filled with 8500 g fine fritted clay, packed and settled, and thoroughly rinsed. Lysimeters seeded at a rate of 8 lb seed/1000 ft^2 (2 g seed per pot). Seed was mixed with 200 mL (approximately 725 g) fine fritted clay and spread evenly over pot surface. Seed was covered with an additional 200 mL fritted clay.
Field lysimeter plot	A plot of tall fescue was used to house lysimeters. When lysimeters were placed within the sunken lysimeter sleeve, the turfgrass canopy of the lysimeter was the same height and contiguous with the turfgrass canopy of the surrounding field plot of tall fescue.
Experimental design	Randomized complete block design, five replications.
Fertilization	All turfs fertilized weekly with a nutrient solution (20 N-20 P_2O_5-20 K_2O plus micronutrients) at 2.44 g N/m^2 (0.5 lb N/1000 ft^2) per month. (Lysimeters were established at 1 lb N/1000 ft^2 per month.) Pots were leached weekly prior to fertilization with RO water to prevent salt buildup.
Mowing	Mowed weekly with a glasshouse reel mower (7-blade reel) at a 50-mm (2-inch) cutting height. Mower had ability to collect clippings for yield.

Table 2. Time frame for tall fescue ET-rate study.

Activity	Date
Lysimeter seeding	Jan. 3 to Feb. 14
Establishment in glasshouse	Feb. 14 to Aug. 22
Field plot seeding and establishment	Feb. 16 to Aug. 22
Weekly fertilizer regime initiated	Aug. 3
Lysimeters moved to field plot for acclimation	Aug. 5
ET Trial A	Aug. 23 to Aug. 26
ET Trial B	Aug. 30 to Sept. 2
ET Trial C	Sept. 6 to Sept. 9
ET Trial D	Sept. 20 to Sept. 23

Table 3. Activity schedule for a typical ET-rate trial.

Day	Activity	Data
Sunday	Plot irrigation (AM)	
Monday	Plot irrigation (AM)	
Tuesday	Saturate and fertilize lysimeters, drain, weigh	
Wednesday	Weigh	ET_1
Thursday	Weigh	ET_2
Friday	Weigh, mow, measure leaves	ET_3, yield, leaf extension rate
Saturday	Plot irrigation (AM)	

Table 4. Tall fescue ET-rate schedule.

Day	Date	Activity	
Friday	Aug. 19	Pots mowed, plot mowed, initial LER measurements (initial)	
Saturday	20	Plot irrigate (42 min)	
Sunday	21	Plot irrigate (42 min)	
Monday	22	Plot irrigate (42 min)	
Tuesday	23	Saturate pots, fertilize, drain, weigh	
Wednesday	24	Weigh	**TRIAL 1**
Thursday	25	Weigh	
Friday	26	LER, weigh, mow plot, mow pots (clipping yield), LER (initial)	
Saturday	27	Plot irrigate (42 min)	
Sunday	28	Plot irrigate (42 min)	
Monday	29	Plot irrigate (42 min)	
Tuesday	30	Saturate pots, fertilize, drain, weigh	
Wednesday	31	Weigh	**TRIAL 2**
Thursday	Sept. 1	Weigh	
Friday	2	LER, weigh, mow plot, mow pots (clipping yield), LER (initial)	
Saturday	3	Plot irrigate (42 min)	
Sunday	4	Plot irrigate (42 min)	
Monday	5	Plot irrigate (42 min)	
Tuesday	6	Saturate pots, fertilize, drain, weigh	
Wednesday	7	Weigh	**TRIAL 3**
Thursday	8	Weigh	
Friday	9	LER, weigh, mow and fertilize plot, mow pots (clipping yield), LER (initial)	
Saturday	10	Plot irrigate (42 min)	
Sunday	11	Plot irrigate (42 min)	
Monday	12	Plot irrigate (42 min)	
Tuesday	13	Saturate pots, fertilize	
Wednesday	14	Leaf density measurements	
Thursday	15	Leaf density measurements	
Friday	16	Leaf length and width measurements, mow plot and pots	
Saturday	17	Plot irrigate (42 min)	
Sunday	18	Plot irrigate (42 min)	
Monday	19	Plot irrigate (42 min)	
Tuesday	20	Saturate pots, fertilize, drain, weigh	
Wednesday	21	Weigh	**TRIAL 4**
Thursday	22	Weigh	
Friday	23	LER, weigh, mow plot, mow pots (clipping yield)	

LER = Leaf extension rate (see Table 6 for details).

Table 5. Environmental data during ET-rate assessments of tall fescue (Aug. 22 to Sept. 25, 1994).

Date		ET_o (mm/day)	Solar radiation ($W/m^2/day$)	Air temp. avg. (ºC)	Wind avg. (m/s)	Relative humidity avg. (%)
August	22	4.28	261	21	1.6	53
	23	5.70	283	23	1.6	47
Trial 1	24	6.03	288	25	1.7	42
	25	5.96	288	26	1.6	39
	26	3.35	169	25	1.4	50
	27	5.64	265	26	1.7	46
	28	5.95	273	26	1.8	43
	29	5.55	280	24	1.7	45
Trial 2	30	5.20	271	22	1.7	54
	31	4.17	208	21	1.6	56
September	1	4.71	229	22	1.6	53
	2	5.03	257	21	1.7	53
	3	5.23	263	22	1.7	50
	4	5.27	252	24	1.5	48
	5	5.64	248	26	1.7	44
	6	6.00	255	27	1.8	36
Trial 3	7	5.74	254	26	1.7	38
	8	5.70	262	25	1.7	38
	9	5.45	242	26	1.6	36
	10	5.37	249	23	1.8	43
	11	4.93	255	20	2.2	51
	12	4.23	–	17	1.8	57
	13	4.48	245	18	1.7	53
	14	4.79	250	21	1.6	45
	15	5.30	254	25	1.7	38
	16	4.75	241	24	1.6	44
	17	4.03	202	22	1.3	51
	18	4.08	214	22	1.4	52
	19	4.32	232	20	1.4	54
	20	4.37	228	20	1.5	51
Trial 4	21	4.40	219	21	1.6	51
	22	4.70	222	23	1.8	47
	23	4.27	217	22	1.8	50
	24	3.33	166	21	1.5	55
	25	4.11	237	21	1.6	64

Data collected from an on-site CIMIS weather station.

Table 6. Morphological measurements taken during tall fescue ET-rate study.

Measurement	Description
Clipping yield	Clippings from each lysimeter collected via a specially constructed glasshouse mower. Clippings dried at 60 ºC for 48 hours prior to weighing. Data reported as mg/lysimeter per 7 days.
Leaf extension rate	Represented the height of 20 randomly selected leaf blades measured immediately following mowing and repeated 7 days later, prior to the next mowing. The height of a leaf blade was the vertical height from the tip of the lysimeter. Data were reported as mm/day, though data were collected as mm/7 days.
Leaf density	Represented the number of leaves individually counted in a 0.5 dm^2 (7.7-in^2) grid. One subsample was measured from each lysimeter. Data were converted to number of leaves/dm^2 (15.5 in^2).
Leaf length and width	Represented the length of 30 leaves measured from each lysimeter, and the width of 30 leaves measured from each lysimeter.
Visual turfgrass quality	Measured on a scale of 1 to 9 where: 1 = worst tall fescue, 5 = minimum acceptable tall fescue and 9 = best tall fescue.

Table 7. Visual turfgrass quality of seven tall fescue cultivars.

	Visual turfgrass quality[z]		
Cultivar	Sept. 6	Oct. 7	Overall mean
RF 1	6.8	6.8	6.8
Shortcut (JC 12)	6.6	6.9	6.8
Tomahawk	7.0	7.0	7.0
Monarch	6.0	6.7	6.4
Bonsai	6.6	6.9	6.8
Amigo	6.2	6.9	6.6
Falcon	6.0	5.9	5.9
LSD, *P* = 0.05	0.5	0.4	0.3

[z] Visual turfgrass quality measured on a scale of 1 to 9: 1 = worst tall fescue; 5 = minimum acceptable tall fescue; and 9 = best tall fescue.

Table 8. Evapotranspiration rates (ET) of seven tall fescue cultivars, maintained under well-watered, field conditions.

Cultivar	ET rate (mm/3 days)				Accumulative ET (mm/12 days)
	8/23-8/26	8/30-9/02	9/06-9/09	9/20-9/23	
Falcon	19.8	15.2	20.4	14.2	69.6
Amigo	19.9	15.1	20.4	15.0	70.4
Bonsai	19.9	14.9	19.8	13.9	68.5
Monarch	20.6	15.2	20.5	13.8	70.1
RF 1	21.0	15.3	20.8	14.3	71.4
Shortcut (JC 12)	20.7	15.3	20.2	14.3	70.5
Tomahawk	20.6	15.6	21.3	15.0	72.5
LSD, $P = 0.05$	0.9	NS	NS	0.9	NS
Mean (mm/day)	6.8	5.1	6.8	4.8	5.9

Table 9. ET-rate studies involving well-watered tall fescue.

Authors	Number of tall fescue cultivars evaluated	Location of evaluation	Percent difference between high and low cultivars[z]	Mean 1-day ET rate (mm)
Kopec, et al.	6	Field	12%	6.8
Bowman and Macaulay	20	Glasshouse	14%	9.1
Green, et al.[y]	22	Field	13%	5.9

[z] $$\left[\frac{(highest - lowest)}{highest}\ x\,100\right]$$

[y] The data presented in Table 8 involving seven cultivars was part of a larger study evaluating 22 cultivars. However, only the seven cultivars reported in the current study were evaluated for clipping yield and other morphological characteristics.

Table 10. Clipping yields of seven tall fescue cultivars maintained under well-watered, field conditions.

Cultivar	Clipping yield (mg/lysimeter per 7 days)				28-day total
	8/23-8/26	8/30-9/02	9/06-9/09	9/20-9/23	
Falcon	557	620	401	447	2025
Amigo	374	456	343	469	1652
Bonsai	476	469	323	322	1606
Monarch	433	456	338	337	1594
RF 1	357	381	269	297	1287
Shortcut (JC 12)	316	277	271	222	1139
Tomahawk	203	297	293	261	1098
LSD, $P = 0.05$	158	110	NS	105	313
Mean	401	430	320	343	1542

Table 11. Leaf extension rates of seven tall fescue cultivars maintained under well-watered, field conditions.

Cultivar	Leaf extension rate (mm/day)				Overall mean
	8/19-8/26	8/26-9/02	9/02-9/09	9/16-9/23	
Shortcut (JC 12)	1.8	2.6	2.1	2.6	2.3
RF 1	1.9	3.0	2.6	2.9	2.6
Tomahawk	1.7	3.0	2.2	3.7	2.6
Bonsai	2.6	3.6	3.1	3.1	3.1
Amigo	2.7	3.2	3.4	3.6	3.2
Monarch	2.9	3.5	3.2	3.4	3.3
Falcon	3.0	4.0	3.3	3.9	3.5
LSD, $P = 0.05$	0.6	0.6	0.4	0.4	0.2

Table 12. Leaf density, length, and width of seven tall fescue cultivars maintained under well-watered, field conditions.

Cultivar	Leaf density (leaves/dm^2)[z]	Leaf length (mm)	Leaf width (mm)
Shortcut (JC 12)	565	37	1.8
RF 1	437	40	2.2
Bonsai	367	41	2.2
Falcon	269	48	2.3
Monarch	296	45	2.3
Tomahawk	336	42	2.4
Amigo	278	46	2.6
LSD, P = 0.05	65	3	0.2

[z]1.0 dm^2 = 15.5 in^2.

Table 13. Correlation coefficients between ET rates or clipping yields and several above-ground morphological characteristics among seven cultivars of tall fescue.

Morphological characteristics	ET rate[z]	Clipping yield
Leaf density	0.17	–0.56**
Leaf extension rate	–0.16	0.87***
Leaf length	–0.15	0.60***
Leaf width	–0.02	0.39*

*,**,***Significant at P = 0.05, 0.01, and 0.001, respectively. The 0.001 significance level is greater than the 0.01 significance level which is greater that the 0.05 significance level. Correlation coefficients not followed by (*) are not significant. A (+) correlation indicates that as one variable increases the second variable increases or as one variable decreases the second variable also decreases. A (–) correlation indicates that as one variable increases or decreases the second variable does the opposite.

[z]The correlation coefficient between the ET rate and clipping yield was –0.04, and was not significant.