CHAPTER III

ET OF TALL FESCUE TURF.

ABSTRACT

The acceptance of tall fescue (*Festuca arundinacea* Schreb.) as a turfgrass species is enhanced by its drought avoidance relative to other C-3 grasses and the recent development of cultivars better adapted to turf related stresses. With this trend, it has become important to determine Evapotranspiration (ET) rates and water use on a cultivar basis.

In a field study, mini-lysimeters were used to measure ET on a ground (ET_{GA}) and leaf area (ET_{LA}) for the cultivars Rebel, K-31, Houndog, Adventure, Kenhy and Mustang. ET was assessed 4 times during the summer of 1984. Measurement periods consisted of 4 consecutive days per time. Crop coefficients (Kc) and the fraction of available water were calculated to determine the soil-plant-atmospheric-continuum (SPAC) relationships for these cultivars under turf conditions. Daily ET_{GA} rates, ET per measurement period and seasonal ET was greatest for Kenhy and K-31, and least for Mustang and Rebel.

Cultivars were heterogeneous for leaf area index (LAI), with values ranging from 2 to 5. LAI differed by cultivar for one of two time periods only. ET_{LA} increased statistical power and cultivars changed rank relative to traditional ET_{GA} estimates. A negative

relationship was found between LAI and ET_{LA}. Cultivars with large LAI values had reduced ET on the leaf area basis. Cultivars differed in their ability to avoid visual wilt symptoms by meeting evaporative demand and using a greater amount of the fraction of available water. Rebel and Mustang used less available water, had lower Kc values, and tended to wilt earlier and more severely than other cultivars tested. Adventure and Houndog had high Kc values, used a greater fraction of available water, and exhibited minimal wilt. These results show that under mowed turf conditions, tall fescue cultivars exhibit differences in ET_{GA} and ET_{LA} rates, water use per period, seasonal water use, Kc ratio, wilt expression and soil moisture use.

Introduction

Tall fescue (*Festuca arundinacea* Schreb.) is increasingly becoming an accepted turfgrass species, particularly since the development of turf-type cultivars (Funk, 1981). These turf-types have increased shoot density, narrower leaves, darker color, more uniform growth, improved disease resistance and mowing qualities compared to cultivars previously used (Funk, 1984). Tall fescues summer performance was evaluated as good compared to other cool season turfgrasses (Beard, 1973). This performance may be in part, attributable to tall fescues deep and prolific root system (Beard, 1973; Youngner et al., 1981).

Evapotranspiration was defined as the total amount of water lost from soil by evaporation and by transpiration from the plants growing thereon (Beard, 1973), and expressed im mm day^{-1}. In turf, the soil component is usually minimal. ET has been determined for tall fescue when compared to other species (Kneebone and Pepper, 1982; Feldhake, 1983; Kim, 1983) or under different management practices (Kim, 1983), but not on an intraspecific basis as turf. With the increased use of tall fescue as a low energy turf, it is important to gain an improved understanding of tall fescue water requirements.

The objectives of this study were to determine the ET rates of tall fescue on a ground and leaf area basis for tall fescue cultivars, and determine the water use of tall fescue cultivars when mowed at 76 mm.

Materials and Methods

Six tall fescue cultivars representing diverse growth habits and genetic origins were established in mini-lysimeters placed within contiguous 1.8 X 1.8 m field plots at the University of Nebraska Agricultural Research and Development Center, located near Mead, Nebraska. Lysimeters were seeded at 35 g m^{-2}. Cultivars used in this study were Mustang, Adventure, Houndog, and Rebel which were specifically developed as improved turf-types. The cultivar Kenhy (forage type) and Kentucky 31 (intermediate) were included since they have been used as utility turfs. Field plots and lysimeters received 5 g N m-2 of starter fertilizer (18N-11P-5K) when establised in May 1983. An additional 7.5 g N m^{-2} was applied the following fall.

Four ET time periods, each lasting 4 consecutive days were conducted during the summer of 1984. The four times were as follows: T_1 = 14 to 17 July, T_2 = 26 to 29 July, T_3 = 14 to 17 August, and T_4 = 2 to 5 September. Daily ET rates on traditional ground area basis (ET_{GA}) were measured for all four times. Water use per time period (4 day total) and seasonal ET (16 day total) were also calculated. ET_{LA} was determined for T_3 and T_4 by estimating leaf area using a nondestructive technique (unpublished). The crop coefficient (Kc) was determined as ET(actual) / ET(potential) using the Nebraska modified Penman equation as the empirical atmospheric demand. The fraction of available water was determined daily using volumetric water contents (VWC) based on the desorption curve for this soil using the formula

$$\frac{\text{(VWC at time (t) - VWC at 15.0 bars)}}{\text{(VWC at 0.3 bar - VWC at 15.0 bars)}}$$

These values were plotted against the crop coefficient for each of the 16 days, per cultivar. Visible wilt symptoms were assigned to each lysimeter based on extent and severity of leaf rolling using a scale of 1 to 5 were 1= none, 2=slight, 3=modedrate, 4=moderate-severe, and 5=severe.

Experimental design was a randomized complete block with four replications. Cultivar significance was determined by the analysis of variance and mean separation using Duncans's multiple range test.

Lysimeters were constructed out of 20 cm diameter PVC pipe cut to 33 cm lengths (Rogowsky, 1977). Plexiglass bottoms glued to the inside of the lysimeter had four 4.5 cm holes for drainage. Each hole was chamfered to accept a triple layer of burlap which protruded 1 cm from the bottom of the plexiglass to establish contact with the substrata to enhance drainage and capillary movement when the lysimeter was not in the ET measurement phase. This design had been demonstrated to allow soil water to move in or outside the lysimeter even after repeated removal and replacement

(Rogowsky, 1977). Lysimeters were carefully packed to a bulk density of 1.25 g cm_{-3} with a 2.5 cm headway. A percolation diverter of duct tape was inserted on the inside of the lysimeter wall at 15 cm forming a right angle at the soil surface to prevent water from passing directly down the lysimeter wall. Lysimeters were inserted into liner sleeves 0.6 cm larger in diameter which were made by lapping and rivetting 25 cm PVC pipe. Two 0.6 cm holes were drilled at a 180 o angle at soil level to accommodate a jig for removing and installing lysimeters.

The method used for determining daily water loss was described elsewhere (Kim, 1983) with the exception that the lysimeter bottom was fit to a plastic sleeve to break soil contact. Lysimeters were drained in place for 24 hours to obtain gravitational water content. Lysimeters were weighed to the nearest gram using a Mettler PE 24 digital readout scale. At the end of the fourth day, ET was terminated and lysimeters were unsealed and replaced in the test area.

Results and Discussion

Daily ET_{GA} rates were significant for 8 of the 16 days. ET_{GA} rates were not significant on a cultivar basis the first day of each time period, except on August 14.

For the period T_1, cultivars had significantly different ET_{GA} rates for 15, 16 and 17 July (Figure 1) and for four day total ET_{GA}. Houndog and Adventure had the highest ET_{GA} rates, while Rebel and Mustang had the lowest (Figure 1). This was the trend on a daily basis during T_1 and for the four day total ET_{GA}. Cultivar wilting was inversely related to ET. Rebel and Mustang had low ET rates and totals and high tendencies to wilt.

For periods T_2, T3 and T4, Kentucky 31 and Kenhy had the highest four day total ET_{GA} (Figures 2, 3 and 4). This result was significant for T_3 and T_4. Cultivars did not differ for daily or 4 day total ET_{GA} during T_2 (Figure 2).

During the period T_3, cultivar ETGA rates were significant on August 15, 16 and 17. Kenhy and Kentucky 31 had the highest rates, with Houndog and Adventure the least (Figure 3). Cultivars differed for ET_{GA} as Rebel had 15% greater total ET_{GA}.

During the final period T_4, ET_{GA} rates were significant on 4 and 5 August (Figure 4) and for the 4 day total ET_{GA}. Kenhy and Kentucky 31 had the largest

ET_{GA} rates throughout this time, while Rebel had the lowest.

Tall fescue cultivars had significantly different four day ET_{GA} total for time periods T1, T2 and T4 (Figure 5), and for seasonal water use (Figure 6). Seasonal ET_{GA} (for all 16 days) demonstrated that Kenhy and Kentucky 31 had higher ET_{GA} than turf types, especially Rebel and Mustang.

Using the indirect method for estimating LAI allowed for nondestructive determinations of LAI and expression of ET on a leaf area basis (ET_{LA}). For time period T3, cultivar LAI was not significant due to high standard errors for cultivar means (Table 1). LAI values were from 2 to 5 on an individual bucket basis, with cultivar means ranging from 3.6 to 4.6. ET_{GA} rates on 15 August were not significant, while ET_{LA} rates were significant at the 0.06 level (Table 2). Mustang and Adventure had the highest LAI values, while Kenhy, K-31 and Rebel had the lowest.

Cultivar LAI was statistically different for the period T_4 as Mustang and Adventure had large LAI. Kenhy,Kentucky 31 and Rebel had the lowest (Table 1).

A negative relationship existed between LAI and ET_{LA} (Figure 7). Cultivars with high LAI such as Mustang and Adventure had the lowest ET_{LA} rates. Conversely, Kenhy and K-31 which had lower LAI values had the highest

ET_{LA}. These trends were evident throughout the experiment, with the exception of Rebel. This cultivar had low LAI values but ET was most likely diminished by the early onset of wilt. Therefore, the hypothesis that turf-type cultivars use more water and wilt sooner than germplasm previously used under mowed turf conditions is not valid in terms of ET rates or soil moisture availability. Other mechanisms may be involved such as depth and extent of rooting, soil moisture extraction (Tovey, 1969), osmotic adjustment, morphology and arrangement of bulliform cells and sensible heat loss.

The overall relationship between plant wilt, crop coefficient, and fraction of available water based on seasonal ET_{GA} forms the Soil-Plant-Atmospheric-Continuum (SPAC). This relationship is different for these 6 cultivars (Figure 8). Mustang and Rebel had lower Kc values, used less available water, and reached moderate wilt values sooner than other cultivars. Kentucky 31 and Kenhy had higher Kc values, and used a greater amount of soil moisture before the onset of wilting. Among turf-types, Houndog had the largest crop coefficient, used the greatest fraction of available water, and postponed wilt in contrast to Rebel and Mustang. Adventure tall fescue had the second highest Kc values and utilized a large amount of available water, and did not show visible wilting. Adventure had a high mean LAI value, and low ET_{LA} rates. Its ET_{GA} was intermediate. This relationship is in partial agreement with Kim (1983) who stated that turfgrasses with high shoot densities, high leaf areas and decumbent growth habits had low ET_{GA} rates, but his comparisons are inconsistent with his explanation that large ET rates for K-31 (compared to other warm season grasses) was due to a high leaf area. ET_{LA} would have been beneficial in a previous study comparing ET of C-3 and C-4 turfgrasses (Biran et al., 1981) where it was expressed that changes in LAI may have explained differences in ET between C-3 and C-4 grasses when cutting heights were raised from 30 to 60 mm.

These are the first results to show that tall fescue cultivars had significantly different ET_{GA} and ET_{LA} rates under mowed conditions. ET_{LA} rates showed that cultivar differences existed for this variable when cultivar ET_{GA} differences could not be detected. Tall fescue cultivars differed in the visible wilt response, which was not entirely dependent on soil moisture stress. These cultivar relationships are important since irrigation is often scheduled with the onset of visual wilt, and judicious selection of cultivars may be part of a maintenance program facilitating minimum irrigation. In terms of ET and water use, data is available for forage tall fescue and under different management systems (Silcock, 1979; Fairborne 1982), but not previously for turf on a cultivar basis. Tall fescues exhibited differences in using the fraction of available water, maintaining the atmospheric demand for water vapor loss, and avoiding wilt when evaluated jointly with the above variables in (SPAC).

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Table III.1. Leaf area index (LAI) of 6 tall fescue cultivars on two dates, summer 1984, Mead Nebraska.

August 14			September 2		
Cultivar	LAI† Mean	Std. error	Cultivar	LAI Mean	Std. error
Mustang	3.8 a‡	0.38	Adventure	4.7 a	0.18
Adventure	3.8 a	0.14	Mustang	4.6 a	0.35
Rebel	3.5 a	0.55	Houndog	4.1 ac	0.49
Kenhy	3.4 a	0.25	K-31	3.8 bc	0.31
K-31	3.3 a	0.31	Rebel	3.6 bc	0.34
Houndog	3.1 a	0.13	Kenhy	3.5 c	0.43
P>F		0.33	P>F		0.08

†LAI determined using indirect method.
‡Means with the same letter are not significantly different at the 0.05 probability level, DMRT.

Table III.2. ET(GA) and ET(LA) value o six tall fescue cultivars on three dates, summer 1984.

Cultivar	ET(GA)†	Cultivar	ET(LA)
	September 2		
Kenhy	7.1 a‡	Kenhy	2.1 a
K-31	7.0 a	K-31	1.9 ab
Mustang	7.0 a	Rebel	1.8 ab
Adventure	7.0 a	Houndog	1.7 ab
Houndog	6.8 a	Mustang	1.5 b
Rebel	6.3 a	Adventure	1.5 b
P>F	0.31	P>F	0.11
	September 3		
Cultivar	ET(GA)	Cultivar	ET(LA)
K-31	5.0 a	Kenhy	1.4 a
Kenhy	4.9 a	K-31	1.3 ab
Mustang	4.7 a	Rebel	1.2 ab
Adventure	4.6 a	Houndog	1.1 ab
Houndog	4.6 a	Mustang	1.0 b
Rebel	4.3 a	Adventure	1.0 b
P>F	0.27	P>F	0.05
	August 14		
Cultivar	ET(GA)	Cultivar	ET(LA)
Kenhy	8.1 a	K-31	2.5 a
K-31	7.9 a	Kenhy	2.4 a
Mustang	7.8 a	Houndog	2.4 a
Houndog	7.5 a	Rebel	2.2 ab
Adventure	7.3 a	Mustang	2.0 ab
Rebel	7.0 a	Adventure	1.9 b
P>F	0.29	P>F	0.05

†ET(GA) and ET(LA) in units of mm day -1, ground and leaf area respectively

‡Cultivars with the same letter in common are not significantly different at the 0.05 probability level, DMRT.

Figure 1

Daily ET rates during time period T−1 for 6 tall fescue cultivars.

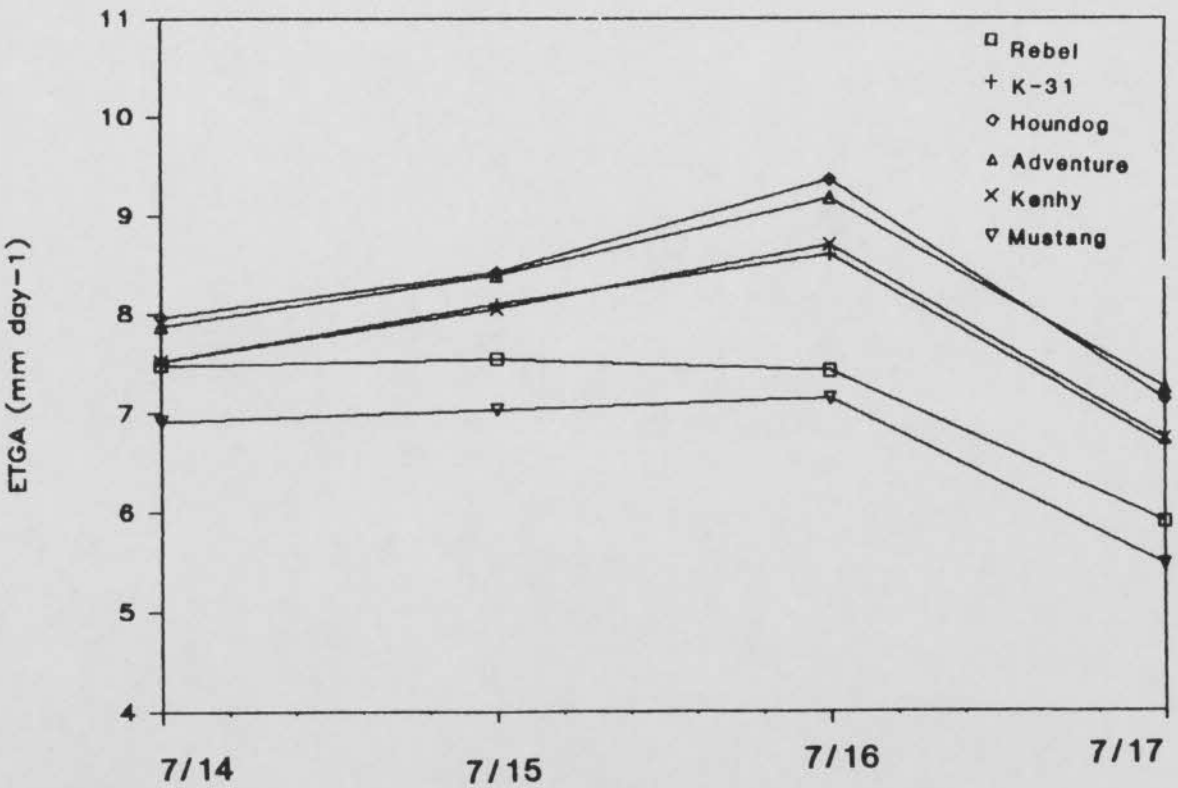


Figure 2

Daily ET rates during time period T−2 for 6 tall fescue cultivars.

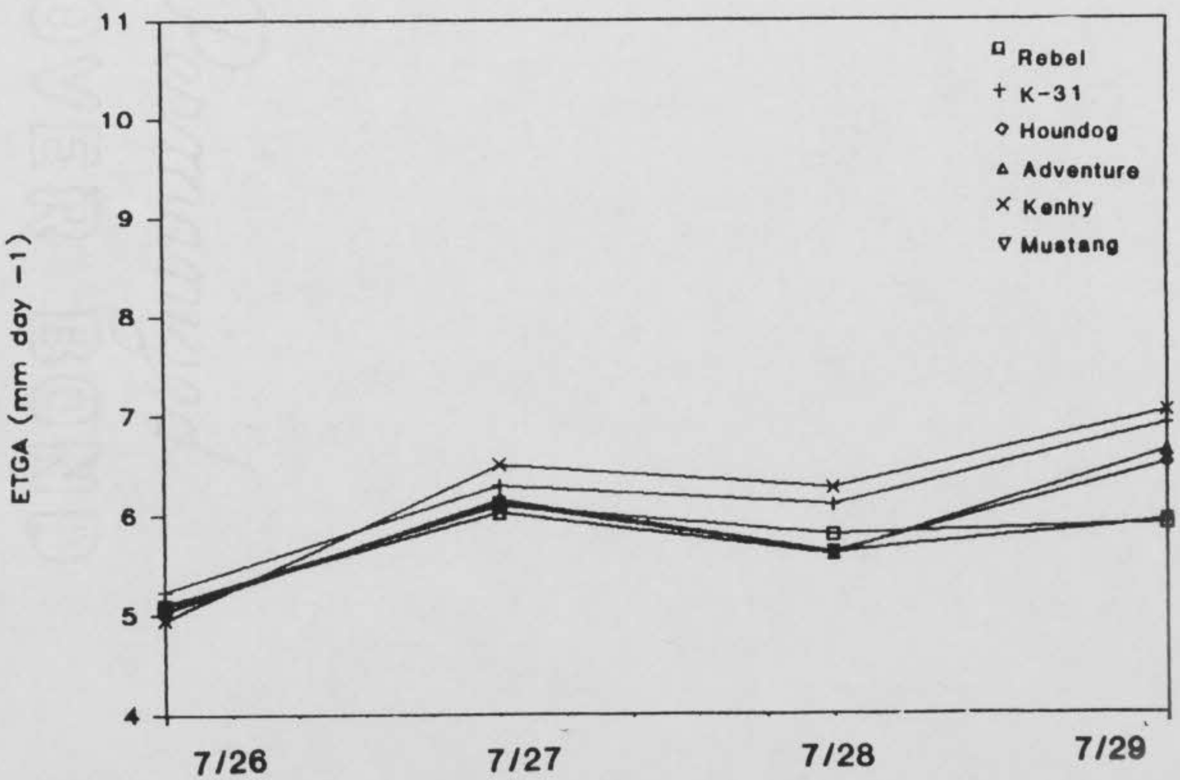


Figure 3

Daily ET rates during time period T−3 for 6 tall fescue cultivars.

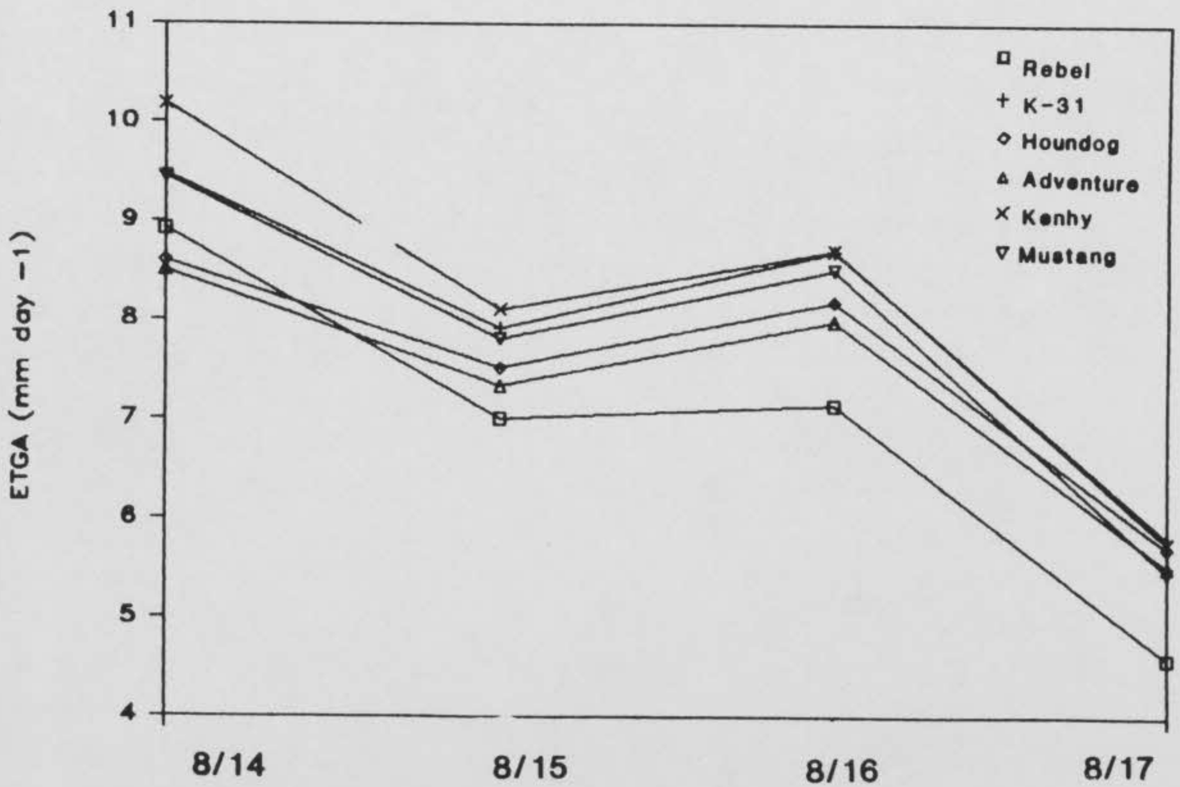


Figure 4

Daily ET rates during time period T-4 for 6 tall fescue cultivars.

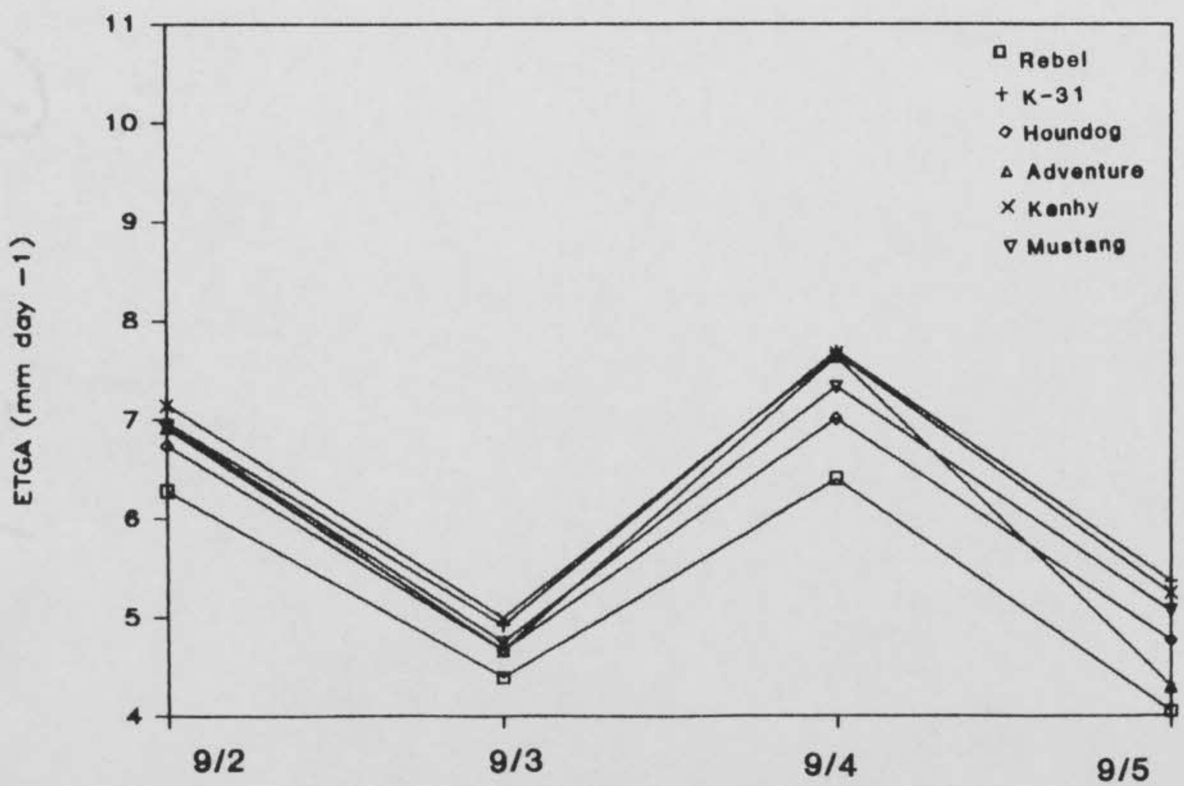


Figure 5

Total water use per time period for 6 tall fescue cultivars

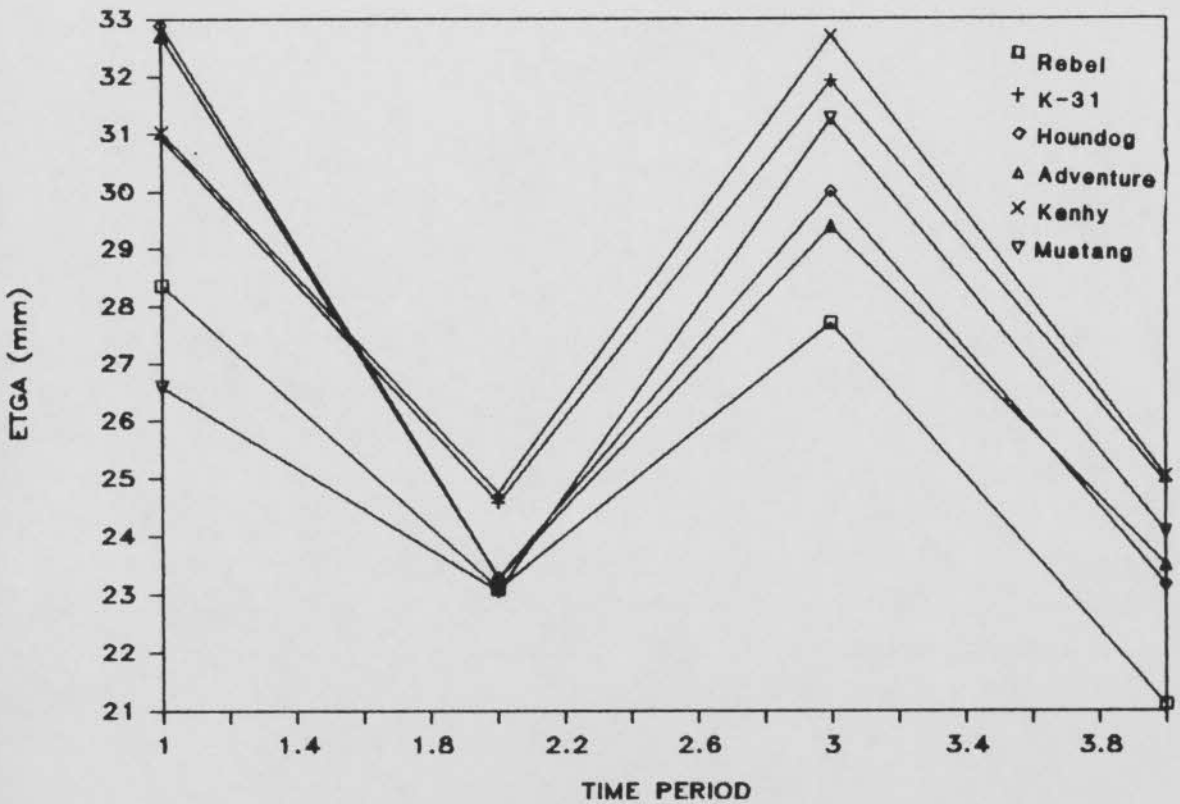
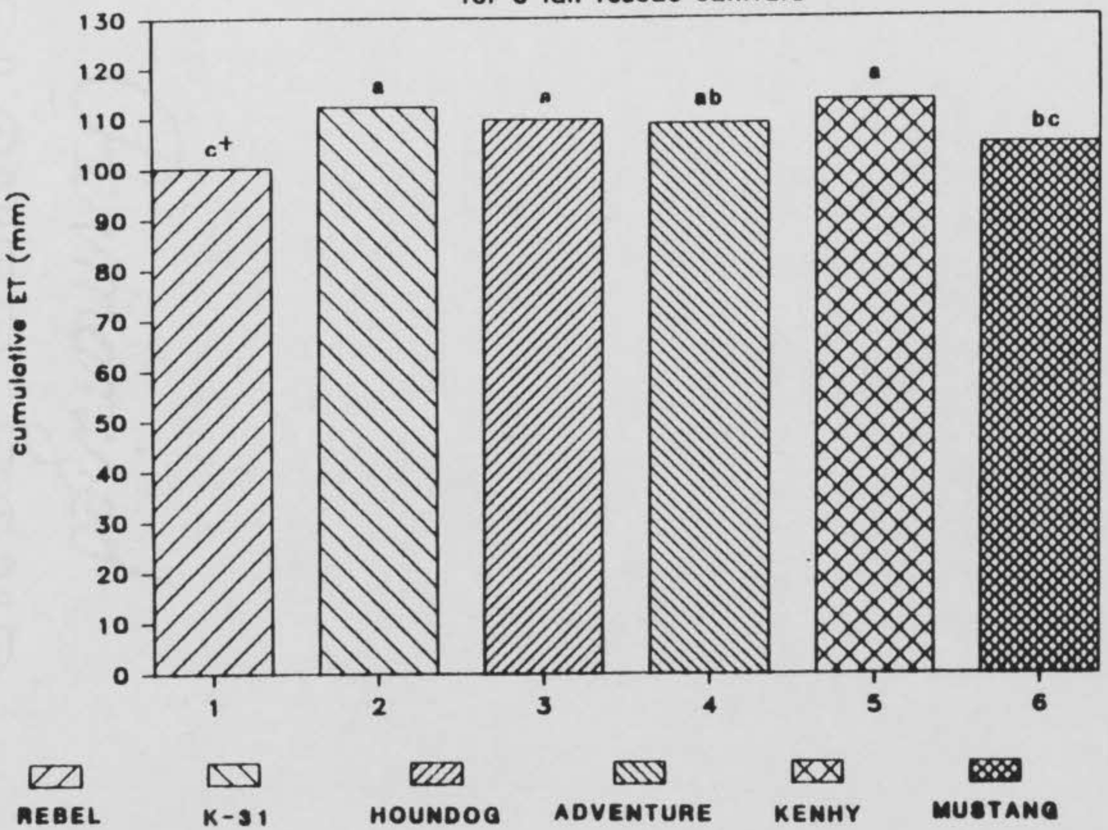


Figure 6.

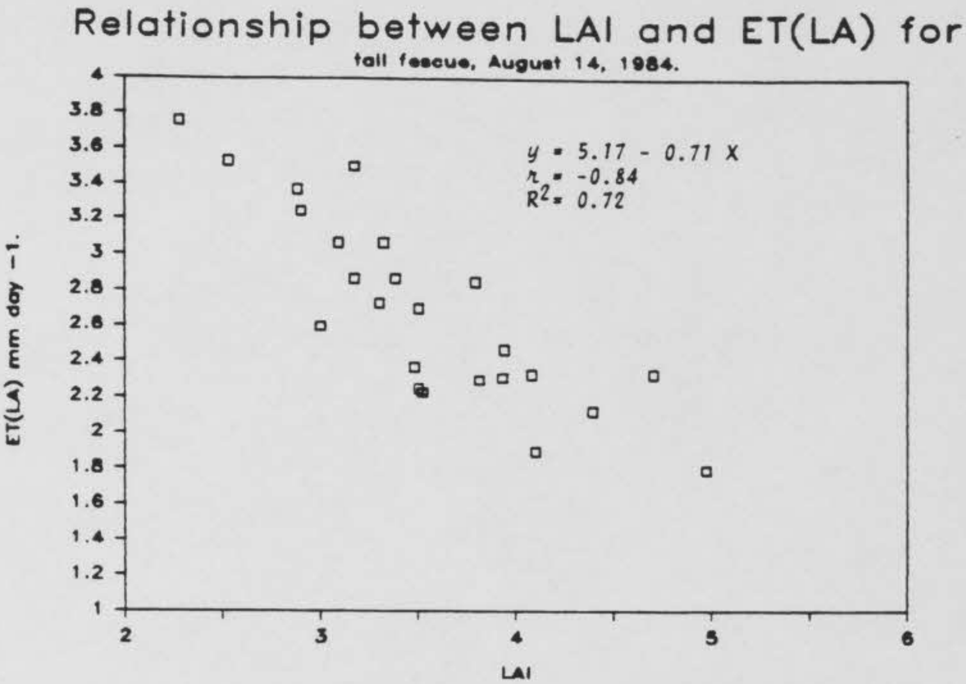
16 day cumulative ET (mm) ground area

for 6 tall fescue cultivars



+ Cultivars with the same letter in common are not significantly different at the 0.05 probability level, DMRT.

Figure 7.


Relationship between LAI and ET(LA) for
tall fescue, August 14, 1984.
y = 5.17 - 0.71 X
r = -0.84
R2= 0.72
ET(LA) mm day -1.
LAI

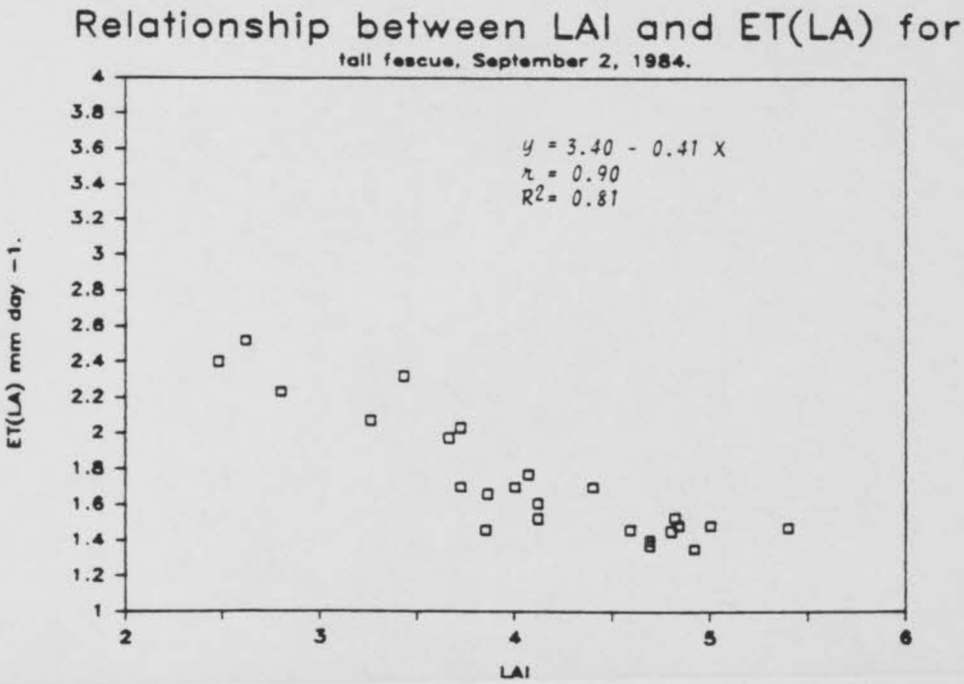
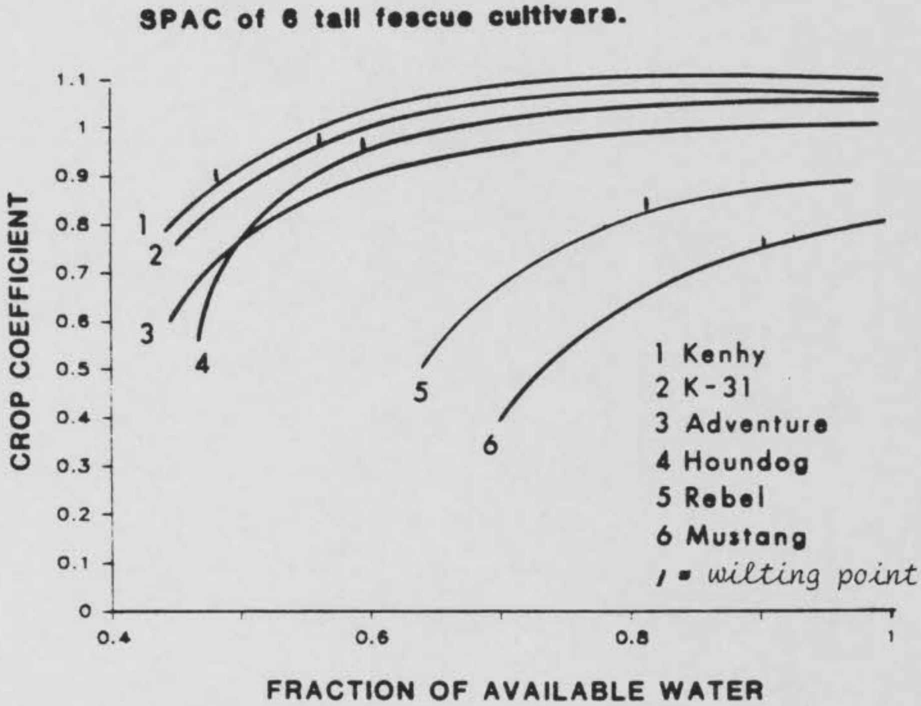

Relationship between LAI and ET(LA) for
tall fescue, September 2, 1984.
y = 3.40 - 0.41 X
r = 0.90
R2= 0.81
ET(LA) mm day -1.
LAI

Figure 8


SPAC of 6 tall fescue cultivars.
CROP COEFFICIENT
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.4
0.6
0.8
1
FRACTION OF AVAILABLE WATER
1 Kenhy
2 K-31
3 Adventure
4 Houndog
5 Rebel
6 Mustang
/ = wilting point