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First-year Response of Turf-type Tall Fescue Cultivars to Different Fertilization Rates and Mowing Heights in Semiarid Conditions

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SUMMARY. Tall fescue (*Festuca arundinacea*) has desirable attributes as a cool-season turfgrass for the semiarid southwestern United States and the transition zone, but effects of cultural practices on newer cultivars within a desert climate are not adequately known. A field study was conducted between Sept. 1996 and Nov. 1997 to evaluate establishment of 15 turf-type tall fescue cultivars under two mowing heights (2 or 3 inches) and two different annual nitrogen (N), phosphorus (P), and potassium (K) application rates (N at 13.2 or 26.4 g·m⁻², P at 0.9 or 1.8 g·m⁻², and K at 11.0 or 22.0 g·m⁻²). The cultivars included 'Amigo', 'Apache', 'Aztec', 'Bonanza', 'Chieftain', 'Cochise', 'Confederate', 'Coronado', 'Crossfire II', 'Falcon', 'Guardian', 'Kentucky 31', 'Leprechaun', 'Shortstop', and 'Virtue'. The fertilizer rate had no effect on turfgrass quality ratings throughout the establishment period, although overall quality was higher in Fall 1997 than during Spring and Summer 1997. The mowing height of 2 inches increased summer quality ratings of 11 of the 15 cultivars as compared with ratings under the 3-inch mowing height. The 2-inch mowing height improved fall quality ratings of seven of the 15 cultivars. No cultivars responded positively to the 3-inch mowing height. Consistently high summer through fall quality ratings were observed when 'Apache', 'Aztec', and 'Crossfire II' were mowed at the 2-inch height as compared with the other cultivar × mowing height treatment combinations. For turf-type tall fescue establishment in semiarid climates, findings support use of a 2-inch mowing height combined with the selective planting of 'Apache', 'Aztec', and 'Crossfire II' over other cultivar × mowing height combinations tested in the study.

Turf-type tall fescue is a popular cool-season turfgrass grown throughout much of the United States. Improved turf-type tall fescue cultivars have been developed to provide desirable traits over older tall fescue cultivars such as 'Kentucky 31'. Such attributes include finer texture, increased wear and pest tolerance, and the ability to withstand lower mowing heights (Harivandi, 1991; Meyer and Funk, 1989; Watschke, 1990).

Tall fescue is a relatively heat- and drought-tolerant cool-season grass (Jiang and Huang, 2001); thus, it can be grown successfully in all parts of semiarid New Mexico. The species is also classified as moderately salt-tolerant (Francois and Maas, 1994), which in New Mexico, supports an increasing reliance on saline effluent and groundwater for nonessential uses to maintain potable water supplies for rising municipal demands (Ruiz et al., 2006).

Limited data are available on performance of turf-type tall fescue cultivars as affected by cultural practices in semiarid conditions of the southwestern United States. Rather, research has been confined largely to the cool-season and transition zones. Two studies on 'Kentucky 31' demonstrated an inverse relationship between mowing height and shoot development, tillering rate, stand uniformity, and stand establishment rate (McKee et al., 1967; Spak et al., 1993). During the first 18 months of establishing 'Rebel II', raising the mowing height from 1.25 to 3.5 inches improved spring through fall stand quality rating but reduced the winter stand quality rating (Dernoeden et al., 1993). During the same span of time in the latter study, increasing the nitrogen (N) application rate from 10 to 20 g·m⁻² per year had no effect on spring and summer stand quality but

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Units

To convert U.S. to SI,
multiply by

0.3048
0.0929
3.7854
2.5400
25.4000
37.0798
1
(°F - 32) ÷ 1.8

U.S. unit

ft
ft²
gal
inch(es)
inch(es)
oz./yard³
ppm
°F

SI unit

m
m²
L
cm
mm
g·m⁻³
mg·kg⁻¹
°C

To convert SI to U.S.,
multiply by

3.2808
10.7639
0.2642
0.3937
0.0394
0.0270
1
(1.8 × °C) + 32

increased the fall through winter stand quality.

Available data pertaining to cultural practices on turf-type tall fescue may not be directly applicable to the relatively high summer temperatures, evaporative demands, and light intensities characteristic of the semiarid southwestern United States. For example, irradiance required for saturation of carbon dioxide exchange rate of tall fescue has been reported at 1000 to 1500 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ (Allard et al., 1991), but natural irradiance during northern Chihuahuan Desert summers (e.g., southern New Mexico) exceeds the latter range by 50% or more (Senock et al., 1991). As a result of the extreme environmental conditions, optimal mowing heights for tall fescue may differ from recommendations previously reported (2 inches) for turf-type cultivars (Burns, 1976). Furthermore, adaptability to southern New Mexico growing conditions among the numerous turf-type tall fescue cultivars while under different mowing heights and fertilization regimes is not adequately known.

In view of the lack of data specific to the semiarid southwestern United States, our objective was to assess visual quality of 15 currently available turf-type tall fescue cultivars during first-year establishment at two mowing heights and two fertilization rates under southern New Mexico conditions. Our intent was to focus on main and interactive effects of cultivar, mowing height, and fertilization rate during individual seasons of spring, summer, and fall.

Materials and methods

The study was completed at the New Mexico State University Fabian Garcia Research Center in Las Cruces between Sept. 1996 and Nov. 1997. During this period, the maximum summer air temperature was 106 °F and the minimum winter air temperature was 10 °F recorded from a weather station ≈ 100 m from the site. The soil was a Glendale fine-silty, mixed, thermic Typic Torrifluent with a pH of 7.3 in the top 8 inches. Total site dimensions were 10 m wide by 46 m long with the length dimension oriented in an east to west direction. The soil was first tilled to a depth of 8 inches and then packed with a tractor-mounted roller. After

packing, the soil surface was hand-raked for leveling and fine-smoothing. No preplant fertilizer was applied. The irrigation system consisted of 10 low-angle popup rotary heads (Rain Bird R-50; Rain Bird Corp., Tucson, Ariz.) spaced at 10-m intervals around the perimeter of the site, each with a flow rate of 2 gal/min and a precipitation rate of 18 mm·h⁻¹.

Fifteen currently available cultivars of turf-type tall fescue were tested, including 'Amigo', 'Apache', 'Aztec', 'Bonanza', 'Chieftan', 'Cochise', 'Confederate' (a blend of cultivars), 'Coronado', 'Crossfire II', 'Falcon', 'Guardian', 'Kentucky 31' (hereafter referred to as 'K-31'), 'Leprechaun', 'Shortstop', and 'Virtue'. Seed of all cultivars was obtained from Pennington Seed (Madison, Ga.) The prepared site was divided into three 151-m² replications. A replication contained 16 m² of perimeter border strip area plus the 15 cultivars, each randomized in 3 × 3-m plots. The cultivar plots were subdivided into four randomly assigned 1.5 × 1.5-m plots (total plot area of 2.25 m²) to contain two mowing height × two fertilization rate treatment combinations described subsequently. For each replication, the direction of mowing (north to south or east to west) was randomly determined and opposite to the direction of fertilizer application (mowing and fertilizing described subsequently).

On 26 Sept. 1996, the plots were seeded with pure live seeds at 50 g·m⁻² using a 2-ft-wide drop spreader followed by hand-raking. Light irrigation was provided three times daily to 12 d after seeding (8 Oct. 1996) when seedlings uniformly covered the area. From 8 Oct. 1996 to termination of the study on 1 Nov. 1997, irrigation was supplied at 3- to 4-d intervals and twice daily (0400 and 1900 HR) to replace between 70% and 80% of total calculated evapotranspiration (ET). To simplify plot maintenance during the growing-in period, all plots were mowed at a single height of 2 inches from ground level with a rotary mower from 23 Oct. 1996 to 5 Jan. 1997. Thereafter, the 2-inch mowing height was maintained on half of the plots with a mowing height of 3 inches imposed on the remaining half of the plots. A ruled template was used as a guide to

ensure that no more than one-third of the turfgrass cover was removed at any given time. All plots were mowed simultaneously one to three times per week, depending on season.

Fertilization was supplied at two rates during the 1997 growing season using 19N-1.3P-15.8K granular turfgrass fertilizer with micronutrients (97% N from sulfur-coated urea; Nu-Grow Corp., Brantford, ON, Canada). On the first week of March, April, May, August, September, and October, low and high fertilization rates provided, respectively, N at 2.2 or 4.4 g·m⁻², phosphorus (P) at 0.15 or 0.30 g·m⁻², and potassium (K) at 1.8 or 3.6 g·m⁻². Annualized, these application rates corresponded to N, P, and K at 13.2, 0.9, and 11.0 g·m⁻², respectively (low fertilization rate) or N, P, and K at 26.4, 1.8, and 22.0 g·m⁻², respectively (high fertilization rate). A low-P fertilizer was selected, because a preliminary soil test indicated that Olsen-P concentration of a composite site soil sample (Olsen et al., 1954) was 110 mg·kg⁻¹, which is considered by the New Mexico Cooperative Extension Service to be high to very high for New Mexico soils (Herrera, 2000). The range in annual N rate (13.2 to 26.4 g·m⁻²) was approximately within the range of N application for tall fescue reported previously [10 to 20 g·m⁻² per year (Dernoeden et al., 1993; Watkins and Meyer, 2004)].

Monthly visual ratings for density, uniformity, texture, color, and overall turfgrass quality were recorded from Mar. 1997 to Nov. 1997 using the methods outlined by Dunn et al. (1994) and Turgeon (1991). Generally similar results were obtained for all rating criteria; thus, only overall turfgrass quality ratings are presented in this report, in which 1 = dead, brown turf to 9 = ideal turf with a minimum acceptable turf quality value of 6. Three-month seasonal averages for quality ratings are reported herein for spring (March, April, and May), summer (June, July, and August), and fall (September, October, and November).

The experimental treatments were replicated three times and arranged as a split plot with cultivar (randomized completely) as the main plot and the mowing × fertilization treatment as the subplot. The analysis of variance for the split plot was

performed separately for each of the three seasons using the SAS PROC MIXED software of SAS (version 6; SAS Institute, Cary, N.C.) to evaluate main effects of cultivar and mowing height and the cultivar $\times$ mowing height interaction. Fisher's protected mean separation tests (least significant difference at $P \leq 0.05$) were used to determine significant differences among relevant means.

Results and discussion

OVERALL SEASONAL QUALITY RATINGS AND FERTILIZER RATE EFFECT. When averaged across cultivars, mowing heights, and fertilization rates, overall quality rating in Fall 1997 was 6.4 as compared with lower overall quality ratings in Spring and Summer 1997 (6.2 and 6.1, respectively), as was somewhat expected for a cool-season grass. For spring, summer, and fall seasons, there were no fertilizer rate main effects or fertilizer $\times$ cultivar interactions; thus, data were pooled across fertilization rates. Although a preliminary soil analysis for total Kjeldahl N was not made, it is possible that residual soil N was sufficient in the low fertilization rate plots to prevent a fertilizer rate effect.

EFFECTS OF CULTIVAR, MOWING, AND THE CULTIVAR $\times$ MOWING INTERACTION WITHIN SEASONS. There were no main effects of cultivar or mowing height or a cultivar $\times$ mowing height interaction during the spring months (Table 1). During spring, quality ratings were at or above the acceptable level of 6, except for quality of 'K-31' (both mowing heights) and quality of 'Virtue' (3-inch mowing height only) (Table 2). During both summer and fall, the main effect of mowing height on quality rating was significant (Table 1), because the 2-inch mowing height plots had a higher overall quality rating than did the 3-inch mowing height plots. Specifically, average summer quality rating at the 2-inch mowing height was 6.3 but only 5.9 at the 3-inch mowing height; in fall, average quality ratings at 2-inch and 3-inch mowing heights were 6.5 and 6.3, respectively (least significant difference, $P \leq 0.05$).

Cultivar interacted with mowing height in both summer and fall months (Table 1). Eleven of the 15 cultivars—'Amigo', 'Apache', 'Bonanza', 'Cochise', 'Confederate', 'Coronado',

'Crossfire II', 'Falcon', 'Leprechaun', 'Shortstop', and 'Virtue'—had a higher summer quality rating at the 2-inch mowing height as compared with the 3-inch mowing height (Table 2). The summer quality ratings of 'Aztec', 'Chieftan',

'Guardian', and 'K-31' were unaffected by the mowing height. Seven of the cultivars ('Amigo', 'Apache', 'Aztec', 'Bonanza', 'Crossfire II', 'Falcon', and 'Shortstop') had a higher quality rating during the fall months when managed under the

Table 1. Probability values for F-tests on main effects of mowing and cultivar and on the cultivar $\times$ mowing interaction for seasonal quality ratings of 15 turf-type tall fescue cultivars during first-year establishment (planted Sept. 1996 and ratings recorded throughout 1997).^z

Source of variation	Probability values		
	Spring	Summer	Fall
Cultivar	0.5403	0.0001	0.0001
Mowing height	0.4997	0.0001	0.0001
Cultivar $\times$ mowing height	0.3334	0.0006	0.0001

^zProbability values from split-plot analysis of variance with cultivar as the main plot and mowing height (pooled across two fertilization rates) as the subplot.

Table 2. Visual quality ratings for 15 turf-type tall fescue cultivars (listed alphabetically) during spring, summer, and fall of first-year establishment (planted Sept. 1996 and ratings recorded throughout 1997).^z

Cultivar	Mowing ht (inches) ^y	Visual quality rating (1–9 scale) ^x		
		Spring	Summer	Fall
Amigo	2	6.7	6.8 a ^w	6.4 c–e*
	3	6.4	6.1 b–h	6.2 d–f
Apache	2	6.1	6.3 a–f*	7.4 a*
	3	6.1	5.9 e–h	7.2 ab
Aztec	2	6.1	6.3 a–f	7.6 a*
	3	6.2	6.2 b–g	7.3 a
Bonanza	2	6.2	6.4 a–d*	6.6 cd*
	3	6.1	6.2 b–g	6.2 d–f
Chieftan	2	6.0	6.0 d–h	6.3 c–e
	3	6.0	5.9 f–h	6.3 c–e
Cochise	2	6.2	6.3 a–f	6.0 ef
	3	6.1	5.8 gh	5.8 f
Confederate	2	6.2	6.2 b–g	6.4 c–e
	3	6.2	5.6 h	6.6 cd
Coronado	2	6.3	6.4 a–d	6.1 d–f
	3	6.6	5.9 e–h	6.1 d–f
Crossfire II	2	6.1	6.8 a	7.1 ab
	3	6.1	6.1 b–h	6.6 cd
Falcon	2	6.0	6.2 b–g*	6.8 bc
	3	6.1	5.9 f–h	6.1 d–f
Guardian	2	6.6	6.1 b–h	6.3 c–e
	3	6.6	6.0 d–h	6.3 c–e
K-31	2	5.8	4.9 i	5.0 g
	3	5.6	5.0 i	5.1 g
Leprechaun	2	6.2	6.6 ab*	6.6 cd
	3	6.2	6.2 b–g	6.4 c–e
Shortstop	2	6.1	6.5 a–c	6.8 bc
	3	6.2	5.9 e–h	6.0 ef
Virtue	2	6.1	6.4 a–d	6.3 c–e
	3	5.8	5.9 e–h	6.2 d–f

^xValues are the means of three replications, each comprised of two 2.25-m² (24.219 ft²) plots.

^yOne inch = 2.54 cm.

^z1 = dead, brown turf; 9 = ideal turf; 6 = minimum acceptable rating.

^wMeans across cultivars and within a seasonal column (subplots across main plots) that share a lower-case letter do not differ by least significant difference ($P \leq 0.05$). An asterisk denotes a significant within-cultivar difference in a column (smaller error term for subplot within main plot) not indicated by lower-case mean separation letters.

2-inch mowing height than when managed under the 3-inch mowing height. Fall quality ratings of the remaining cultivars ('Chieftan', 'Cochise', 'Confederate', 'Coronado', 'Guardian', 'K-31', 'Leprechaun', and 'Virtue') did not depend on the mowing height. Thus, based on number of cultivars, the lower mowing height (2 inches) was more influential in quality enhancement during summer than during fall. For none of the cultivars or during any season did the 3-inch mowing height improve quality ratings.

Summer and fall quality ratings were also affected by the cultivar (Table 1). Consistent with an earlier observation by Watkins and Meyer (2004), 'K-31' had the lowest quality ratings among all the cultivars (Table 2). Relatively high summer quality was observed at the 2-inch mowing height for 'Amigo', 'Apache', 'Aztec', 'Bonanza', 'Cochise', 'Coronado', 'Crossfire II', 'Leprechaun', 'Short-stop', and 'Virtue'. Fall quality ratings of 'Apache' and 'Aztec' (both mowing heights) and of 'Crossfire II' (2-inch mowing height only) were higher than all but two of the remaining 25 cultivar $\times$ mowing height combinations.

PRACTICAL APPLICATION TO A SEMIARID CLIMATE. Results of the present study contribute to a limited database pertaining to cultivar selection and mowing responses of turf-type tall fescue under semiarid conditions. Identification of cool-season turfgrass cultivars that perform well during first-year establishment is essential for a hot desert climate like southern New Mexico. Lowest overall quality ratings for the older 'K-31' relative to the remaining, newer cultivars support application of tall fescue breeding efforts to semiarid conditions, particularly when irrigated at only 70% to 80% of potential ET like in the present study. Relatively high summer through fall quality ratings for 'Apache', 'Aztec', and 'Crossfire II' suggest that these three cultivars are better suited for stand establishment in a semiarid climate than are the remaining cultivars evaluated in this study. Whether this reflects differential heat tolerance of the cultivars or inherent quality traits of cultivars under semiarid conditions remains to be determined.

A preferred mowing height for turf-type tall fescue in a semiarid climate was also an important issue to address in this study. When compared with the 3-inch mowing height, the 2-inch mowing height increased summer quality ratings for most of the cultivars and increased fall quality ratings of approximately half of the cultivars. This result was somewhat surprising in that lower mowing height would be expected to result in a shallower root system than at the higher mowing height, thus reducing the ability of the turfgrass to obtain nutrients and water. Although speculative without the supporting data, it is possible that through a reduction in leaf area, the lower mowing height restricted the potential of the turfgrass to lose water and thereby limited water stress on the stand. Nonetheless, the smaller number of cultivars expressing a positive quality response to the 2-inch mowing height during fall months as compared with the summer months weakened the positive main effect of the lower mowing height across the growing season. Thus, despite a positive main effect of the 2-inch mowing height on quality ratings, the effect may be cultivar-specific, or seasonally specific for some cultivars.

In conclusion, for first-year establishment of turf-type tall fescue in semiarid climates, these preliminary findings support use of a mowing height of 2 inches combined with the selective planting of 'Apache', 'Aztec', and 'Crossfire II' over other cultivar $\times$ mowing height combinations tested in this study. The number of available turf-type tall fescue cultivars is continually increasing (Watkins and Meyer, 2004). Accordingly, the present study should encourage more research on the responses of additional turf-type tall fescue cultivars to various management practices in semiarid climates. Applying research methods on deficit irrigation of turf-type tall fescue in the transition zone (Fu et al., 2004) could be of particular value to the desert southwest turfgrass industry. In light of the preliminary findings, research should also address the physiological bases of mowing height effect and of mowing height interaction with cultivar in the semiarid region.

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