Turf Performance of Mixtures and Blends of Tall Fescue, Kentucky Bluegrass, and Perennial Ryegrass

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Abstract: Various mixtures of tall fescue, *Festuca arundinacea* Schreb., Kentucky bluegrass, *Poa pratensis* L., and perennial ryegrass, *Lolium perenne* L., may be beneficial for turf culture because of genetic diversity and improved tolerance to environmental stresses compared with a single species. Turf-type tall fescue, dwarf tall fescue, Kentucky bluegrass, and perennial ryegrass were seeded as cultivar blends and in all possible combinations as species mixtures in two locations, irrigated and nonirrigated. Turf was mowed at 19 and 51 mm and subjected to an interval of brief, but intensive, simulated traffic. Perennial ryegrass was the dominant species in all mixtures with tall fescue, Kentucky bluegrass, or both. After 5 years, turf-type tall fescue comprised 62% of mixtures with Kentucky bluegrass when averaged over locations. Dwarf tall fescue comprised 48% of mixtures compared with Kentucky bluegrass at 44%. Kentucky bluegrass was more competitive with tall fescue in the irrigated vs. nonirrigated location. Mowing height effected small changes in populations year to year while simulated traffic had little effect on populations at 1 year following treatment. The advantage of mixing species compared with individual species to reduce disease occurrence was evident on several occasions. Our study supports earlier research reports that tall fescue will remain competitive in mixture with Kentucky bluegrass several years after seeding.

Turfgrass mixtures provide greater genetic diversity and may give better tolerance to environmental stress than one species. For this reason, mixtures have potential for better overall quality than any one component species (Donald, 1963). However, for acceptable quality compatible species should possess similar color and vertical growth rate. One species in a mixture should not dominate another species (Beard, 1973).

Tall fescue and Kentucky bluegrass mixtures have been used extensively for athletic fields and sod production (Hall, 1977). Tall fescue has good traffic tolerance while Kentucky bluegrass rhizomes give it better recuperative capability than tall fescue following injury on athletic fields (Turgeon, 1999). For sod production, Kentucky bluegrass rhizomes are considered necessary to give sufficient strength for harvesting sod.

Limited information is available on the quality and compatibility of tall fescue and Kentucky bluegrass in mixture since improved tall fescues were first introduced in 1981 (Funk et al., 1981). According to Brede (1993), “common-type” fescues such as ‘Southern Cross’ are more likely to segregate into patches in mixtures with Kentucky bluegrasses than the newer turf-type (denser and finer textured) tall fescues. Hunt and Dunn (1993), working with turf-type tall fescue cultivars, reported that the

fescue component, seeded at 90% by weight of the mixture, remained competitive with Kentucky bluegrass over 5 years. Also, Brede (1993) reported that seeding mixtures of Kentucky bluegrass with 50% to 75% turf-type tall fescue by seed weight does not cause tall fescue segregation. However, mixtures with perennial ryegrass (*Lolium perenne* L.) may result in suppression of tall fescue because of faster seedling establishment and long term competitiveness of the ryegrass (Harkess, 1970). Hunt and Dunn (1993) reported that tall fescue established as 90% by weight of a seed mixture with perennial ryegrass comprised only 11% of the plant population after 5 years.

Turfgrass mixtures may be influenced by cultural practices such as fertilization, mowing, and irrigation (Davis, 1958). For example, withholding irrigation until all components of the mixture show drought stress would be expected to favor the more drought-tolerant grasses (Hawes, 1977). Traffic may also affect the composition of a turfgrass mixture (Youngner, 1961).

The objective of our study was to determine the practicality of maintaining tall fescue blends in compatible mixtures with blends of perennial ryegrass and Kentucky bluegrass at two cutting heights and two irrigation schedules, and subjected to an interval of short-term but intense, simulated traffic.

Materials and Methods

Cultivars of a turf-type tall fescue (TF1) blend, ‘Rebel II’ + ‘Arid’ + ‘Mustang’, ‘dwarf’ (diminutive and slow growing) tall fescue (TF2) blend, ‘Shortstop’ + ‘Trailblazer’, Ken-

tucky bluegrass (KB) blend, ‘Baron’ + ‘America’ + ‘Merit’, and perennial ryegrass (PR) blend, ‘Palmer’ + ‘Manhattan II’ + ‘Derby’, were seeded as blends and in mixtures with each of the other blends. All blends consisted of equal parts by seed weight of each component cultivar. Each TF blend was seeded at a rate of 244 kg·ha⁻¹, KB at 98 kg·ha⁻¹, PR at 146 kg·ha⁻¹. Two-way mixtures were seeded as 244 TF1 + 24 KB kg·ha⁻¹, 244 TF1 and 24 kg·ha⁻¹ PR, 244 TF2 and 24 kg·ha⁻¹ KB, 244 TF2 and 24 kg·ha⁻¹ PR and 98 KB and 24 kg·ha⁻¹ PR. Three way mixtures were seeded at 122 TF1, 24 KB, and 24 kg·ha⁻¹ PR; and 122 TF2, 24 KB, and 24 kg·ha⁻¹ PR. TF1 and TF2 were also seeded as a composite at a rate of 122 kg·ha⁻¹ of each fescue blend.

The experimental design was a randomized complete block in a split-split plot arrangement with three replications. Data were analyzed using the analysis of variance (ANOVA) procedure of SAS (SAS Institute, Cary, N.C., 1989). Irrigation represents the main plot, entry and irrigation × entry represents the subplot, and mowing and all possible interaction with the main and subplot represents the sub-sub plot. All mean comparisons in the narrative are significant at $P \leq 0.05$.

The experiment was established in Sept. 1991 on a Mexico silt loam soil (fine, montmorillonitic, mesic Mollic Endoaqualls) in two adjacent locations. One location was irrigated as needed to prevent visual drought stress. The other location received no irrigation. Soil in the irrigated location contained 4.4% organic matter (OM), P 105 (kg·ha⁻¹), K at 580, and a pH of 6.8. Nonirrigated soil contained 4.2% OM, 105 P, 525 K, and pH 6.5.

Both locations had previously been planted to a uniform stand of Kentucky bluegrass. Glyphosate [N-(phosphonomethyl) glycine] was sprayed on the bluegrass at 98 kg·ha⁻¹ a.i. ≈30 d prior to seeding the blends and mixtures to kill the existing turf. One day before seeding, the dead turf was mowed to 12 mm and clippings and debris were removed by hand raking. Seedbeds were then prepared by verticutting (Ryan Renothin) until ≈50% of the surface was bare soil. A starter fertilizer (12N–5P–10K) at 30 kg·ha⁻¹ was hand raked into the soil surface. The designated component cultivars of the blends and mixtures were seeded in plots 3.7 × 4.6 m with a drop-type spreader calibrated to deliver each cultivar at the desired rate. The area was lightly mulched with wheat straw and then irrigated as needed to keep the soil surface moist during seedling emergence. Fertilizer was applied at a rate of 48 kg·ha⁻¹ (20N–4P–8K) in mid-October and again mid-November. Beginning in 1992 and for each year thereafter, turf was fertilized with 48 kg·ha⁻¹ (20N–4P–8K) in March, September, October, and November for an annual N total of 192 kg·ha⁻¹/year.

Irrigation was as needed to prevent visual drought stress in the “irrigated” location. Turf was mowed with a 3-reel (triplex) unit two times weekly at 38 mm during establishment. Pendimethalin [N-(1-ethylpropyl)-3,4 dimethyl-2,6 dinitrobenzenamine] was applied to irrigated and nonirrigated locations at 1.68

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kg-ha⁻¹ a.i. in April and May each year to prevent annual grass germination. Broadleaf weeds were controlled as needed with applications of dimethylamine salts of 2,4-D (2,4-dichlorophenoxyacetic acid) at 1.36 kg-ha⁻¹ a.i. + mecoprop [(+)-2-(4-chloro-2-methylphenoxy) propanoic acid] at 0.6 kg-ha⁻¹ a.i. + dicamba (3,6-dichloro-o-anisic acid) at 0.11 kg-ha⁻¹ a.i.

In May 1992, we established mowing heights of 19 mm and 51 mm on one-half of each entry plot. Clippings were left on plots. Simulated traffic was applied to turf only in Oct. 1993. Turf was subjected to 15 passes on one-half of each mowed plot, three times per week for 2 weeks with a modified Brinkman traffic simulator (Cockerham et al., 1990). The simulator weighs 336 kg and has two heavy studded rollers that move at different speeds and compact and tear the turf. We modified the simulator to increase severity of traffic by replacing the welded nuts on the rollers with plastic football cleats, 15 mm long and 12.5 mm diameter.

Turf was evaluated once per month April to November for quality using a rating scale of 1 to 9 (best quality). We estimated severity of diseases as they occurred, using a scale of 1 (no disease) to 9 (100% of turf affected).

An optical-point quadrat was built according to the design of Laycock and Canaway (1980) with 10 fixed optical points spaced 50 mm apart on a wood frame. Ten random settings of 10 fixed points were taken for a total of 100 per treatment unit. Optical point quadrat observations were made in Oct. 1994 and 1995 to estimate TF and KB composition of turf. Based upon preliminary counts, we found that PR dominated mixtures with KB, TF, or mixtures of both species, at 90% or more of the plant population and mixtures containing PR were therefore excluded from further population counts.

Results and Discussion

After five years, mixture populations averaged over the irrigated and nonirrigated locations differed according to cultivar blend and were 62% turf-type tall fescue blend (TF1) vs. 35% Kentucky bluegrass (KB) and 48% dwarf tall fescue blend (TF2) vs. 44% Kentucky bluegrass. Occasional perennial or annual weeds comprised the remaining percentages of the turf mixtures. Previously, Turgeon and Vargas (1977) reported that Kentucky bluegrass and perennial ryegrass in mixtures differed according to cultivar blends selected for each species.

Kentucky bluegrass was more competitive with tall fescue in the irrigated location than the nonirrigated location (Fig. 1). In the nonirrigated location, the average TF population remained constant at 60% to 63% from 1994 to 1995, but increased by 9% from 45% to 54% in the irrigated location. During the same interval, the KB population was not significantly affected by irrigation but averaged over locations decreased from 45% to 32% while the weed population increased by ~10%.

Earlier studies have shown that perennial

Fig. 1. Average percent turf-type and dwarf tall fescues (TF) in irrigated (ir) and nonirrigated (ni) mixtures with Kentucky bluegrass (KB) at 4 and 5 years after seeding. Letters a to c above TF bars indicate significant differences, $P = 0.05$, for the irrigation $\times$ year interaction. There was no significant irrigation $\times$ year interaction for KB.

Table 1. Summer quality^a of tall fescue, Kentucky bluegrass, and perennial ryegrass blends and mixtures 1991–95.

Entry ^y	Irrigation ^x	Year				
		1991	1992	1993	1994	1995
TF1	+	4.8	5.4	4.9	5.7	5.3
TF2	+	4.8	5.3	4.8	5.3	4.8
KB	+	5.4	5.1	5.2	5.3	4.9
PR	+	4.0	4.4	4.9	4.9	5.0
TF1 + TF2	+	4.6	5.0	4.8	5.1	5.0
TF1 + KB	+	5.4	5.4	5.5	5.9	5.4
TF1 + PR	+	4.1	4.5	4.5	4.7	4.9
TF2 + KB	+	5.1	5.2	5.6	6.0	5.5
TF2 + PR	+	4.1	4.5	4.8	4.6	5.0
KB + PR	+	4.6	4.7	4.9	5.4	4.8
TF1 + KB + PR	+	4.8	4.7	4.9	5.0	5.3
TF2 + KB + PR	+	4.6	4.7	5.0	5.2	5.0
TF1	–	5.1	4.8	4.6	4.9	4.8
TF2	–	4.8	4.7	4.4	4.3	3.7
KB	–	4.4	3.7	4.9	3.8	4.2
PR	–	3.2	4.0	4.4	4.5	4.8
TF1 + TF2	–	5.0	4.7	5.1	5.1	5.0
TF1 + KB	–	5.1	4.6	5.3	5.5	5.1
TF1 + PR	–	3.8	4.2	4.4	4.5	4.7
TF2 + KB	–	5.0	4.6	5.3	5.1	4.8
TF2 + PR	–	3.8	4.0	4.4	4.6	4.5
KB + PR	–	3.3	4.0	4.6	4.6	4.7
TF1 + KB + PR	–	4.0	4.5	4.9	4.8	4.8
TF2 + KB + PR	–	3.7	4.1	4.6	4.5	4.7
LSD _{0.05} ^w		0.5	0.4	0.3	0.3	0.3
Source of variation	df					
Irr	1	**	**	NS	**	*
Rep (Irr)	4	0.2277	0.1799	0.2808	0.2721	0.6558
Entry	11	**	**	**	**	**
Irr $\times$ Entry	11	**	*	*	**	NS
Rep (Irr $\times$ Entry)	44	0.1207	0.1227	0.1509	0.0717	0.2326
Mow	1	**	**	**	**	NS
Irr $\times$ Mow	1	NS	NS	NS	**	NS
Mow $\times$ Entry	11	*	NS	**	NS	*
Irr $\times$ Mow $\times$ Entry	11	NS	NS	NS	NS	NS
Error C	48	0.0406	0.0498	0.0515	0.0570	0.0824

^aScale: 1 (dead turf) to 9 (highest quality). Values represent averages of monthly ratings Jun, Jul, Aug, Sept.

^yTF1 = Tall fescue turf-type blend of cultivars Rebel II + Arid + Mustang; TF2 = tall fescue dwarf blend of cultivars Shortstop + Trailblazer; KB = Kentucky bluegrass blend of cultivars Baron + America + Merit; PR = perennial ryegrass blend of cultivars Palmer + Manhattan II + Derby.

^x+ = irrigated; – = nonirrigated.

^wFor comparison of entries within an irrigation regime or a single entry between irrigation regimes.

*, **Significant at $P \geq 0.05$, 0.01, respectively.

ryegrass (PR) in mixtures may dominate TF and KB regardless of management. Based upon two years of observations, Brede and Duich (1984b) suggested that a KB + PR seed mixture should contain $\approx 50\%$ to 85% KB for adequate KB establishment. However, our study indicates that a KB + PR seeding mixture containing only 10% PR by seed weight will eventually be dominated by PR. This finding supports the earlier research of Hunt & Dunn (1993) who reported that all mixture combinations of TF and KB containing PR were dominated by PR after 5 years. Likewise, Hsiang et al (1997) reported that a seeding mixture of 90% KB to 10% PR by seed weight was dominated by PR after 4 years. Reports by Brede and Duich (1984a) and Hall (1977) showed that mowing had an early effect on the balance of TF and KB in mixture. Our research indicates that mowing may effect small year to year changes in mixture populations. In our study, TF mowed at 19 mm increased slightly from 53% to 59% from 1994 to 1995 while KB decreased from 46% to 29% . However, at the 51 mm cutting height, TF was unchanged 1994 to 1995 at 55% while the KB population decreased from 43% to 34% . The TF1 blend was somewhat more competitive at 19 mm (65%) than 51 mm (60%), compared with 47% at 19 mm and 51% at 51 mm for the TF2 blend. Weeds increased from an average 2% in 1994 to 12% of the population in 1995, but were unaffected by mowing height.

The Kentucky bluegrass blend and some mixtures containing KB showed more rapid recovery than the tall fescue blend at eight weeks following simulated traffic. However, all entries were in poor condition at this time with maximum quality averaged over locations of only 2.5 ($9 = \text{best quality}$). The harmful effect of traffic on blends and mixtures was still apparent in May, 1994, ≈ 7 months after traffic was imposed on turf, with average nontrafficked turf quality of 6.4 vs. 5.3 for trafficked turf. However, there were no significant differences among mixtures and blends at this time. By mid-June, the influence of traffic was no longer visible, 5.6 nontrafficked vs. 5.4 trafficked. Population counts 1 year after traffic showed that trafficked KB decreased from 39% to 36% of mixture compared with nontrafficked turf at the 19-mm cutting height and increased from 36% to 41% at the 51-mm cutting height. Otherwise, there was no prolonged effect of intense, short term traffic.

Summer quality (June–Sept.) of irrigated plots was generally better than that of nonirrigated plots for the duration of the study, 1991–95. However, there were significant interactions as nonirrigated turf quality occasionally equaled or exceeded that of irrigated turf (Table 1). The main effect for irrigation was nonsignificant only in 1993 when turf received above normal rainfall May through September (Fig. 2). Mixtures sometimes gave better quality than either species as blends. For example, TF + KB often gave superior quality compared with the TF blend and, especially, the KB blend, over the 5-year period. This response may be attributed on occasion to

Fig. 2. Average monthly precipitation and temperatures, 1991–95, Univ. of Missouri South Farms Turfgrass Research Center, Columbia, Mo.

better disease resistance of the mixture compared with individual components.

When mowing effect was significant (Table 1), quality of entries improved with higher mowing. The mowing $\times$ entry interaction on quality was significant (Table 1) in 1991, 93, and 95. For example, in 1991, TF2 + PR quality was better at 51 mm compared with 19 mm while TF2 + KB quality was unaffected by mowing height (data not shown).

The advantage of mixing species was evident in May 1991 when dollar spot caused by *Sclerotinia homeocarpa* F.T. Bennett was rated. The PR + KB mixture had less dollar spot, 2.5 rating, than the PR blend, 5.3 rating (Table 2). Dollar spot was the most prevalent disease during the 5-year study and mostly affected PR with little occurrence in KB. Presumably, PR and KB populations were more balanced in mixture in 1991 compared with 1994, so that the positive influence of KB on less dollar spot in the mixture would be more apparent early in the study. Although no population counts were made in 1991, Hunt and Dunn (1993) reported that a mixture of TF and PR was evenly balanced early in their study at 45% of each species 2 years after seeding. Three years after seeding in the present study, when PR dominated mixtures, the advantage of mixing species was still apparent,

but dollar spot became more evident in the mixture as the competitive influence of Kentucky bluegrass and tall fescue declined. At this time, PR received a disease rating of 5.3 vs. 2.7 for TF2 + KB + PR (Table 2).

Infestations of brown patch caused by *Rhizoctonia solani* Kuhn were observed mostly in TF and occasionally PR, but were often less evident in mixtures compared with species blends (Table 3). Irrigation sometimes influenced disease but this effect was dependent on species affected. For example, in 1994, PR dominated plots were heavily infested with dollar spot and irrigated plots were most severely affected (average 4.3 vs. 2.8 for nonirrigated). However, brown patch in 1992 was more apparent in nonirrigated plots, perhaps because TF turf took longer to recover from disease injury in that location compared with irrigated turf. The interaction for entry $\times$ mowing on *Rhizoctonia* incidence was significant in July, 1992 (Table 3). TF1 + TF2, PR, and mixtures containing PR had greater disease infestation at 51 mm while TF1 + TF2 and TF + KB mixtures were unaffected by mowing height (data not shown).

Previously, Hunt and Dunn (1993) reported that a mixture of tall fescue and Kentucky bluegrass appeared to stabilize after 4 years. However, results of our study suggest that

Table 2. Dollar spot ² in blends and mixtures.

Entry ³	Disease rating	
	May 1991	July 1992
KB + PR	2.5	4.2
PR	5.3	4.2
TF2 + PR	4.3	4.2
TF2 + KB + PR	2.3	3.8
KB	1.0	3.2
TF1 + KB + PR	2.7	3.1
TF1 + PR	3.2	3.0
TF2	1.0	1.5
TF1	1.2	1.3
TF2 + KB	1.2	1.3
TF1 + KB	1.1	1.2
TF1 + TF2	1.0	1.1
LSD _{0.05}	0.8	1.1
Source of variation	df	
Irr	1	NS
Reg (Irr)	4	4.4097
Entry	11	**
Irr × Entry	11	NS
Rep (Irr × Entry)	44	1.1370
Mow	1	NS
Irr × Mow	1	*
Mow × Entry	11	NS
Irr × Mow × Entry	11	NS
Error C	48	0.1736

²Scale: 1 (no disease) to 9 (100% of turf affected). Values represent means of three replications per entry.

³TF1 = Tall fescue turf-type blend of cultivars Rebel II + Arid + Mustang; TF2 = tall fescue dwarf blend of cultivars Shortstop + Trailblazer; KB = Kentucky bluegrass blend of cultivars Baron + America + Merit; PR = perennial ryegrass blend of cultivars Palmer + Manhattan II + Derby.

*,**Significant at $P \leq 0.05$, 0.01, respectively.

Table 3. Brown patch² in blends and mixtures.

Entry ³	Disease rating	
	July 1992	July 1993
TF2	2.7	4.6
TF1 + PR	1.7	4.5
TF1	2.3	4.3
TF2 + PR	1.0	3.9
TF1 + TF2	2.6	3.8
PR	1.0	3.3
KB + PR	1.0	3.3
TF2 + KB + PR	1.3	3.1
TF1 + KB + PR	1.3	3.0
TF1 + KB	2.1	2.6
TF2 + KB	2.3	2.3
KB	1.0	1.7
LSD _{0.05}	1.0	1.1
Source of variation	df	
Irr	1	NS
Rep (Irr)	4	0.9028
Entry	11	**
Irr × Entry	11	NS
Rep (Irr × Entry)	44	1.2285
Mow	1	NS
Irr × Mow	1	NS
Mow × Entry	11	NS
Irr × Mow × Entry	11	NS
Error C	48	0.3403

²Scale: 1 (no disease) to 9 (100% of turf affected). Values represent means of three replications per entry.

³TF1 = Tall fescue turf-type blend of cultivars Rebel II + Arid + Mustang; TF2 = tall fescue dwarf blend of cultivars Shortstop + Trailblazer; KB = Kentucky bluegrass blend of cultivars Baron + America + Merit; PR = perennial ryegrass blend of cultivars Palmer + Manhattan II + Derby.

*,**Significant at $P \leq 0.05$, 0.01, respectively.

environmental factors such as rainfall could account for significant annual population swings beyond 4 years. For example, in May 1995, rainfall of 281 mm (Fig. 2), 30% of the annual total for that year, may have hastened degradation of an April pre-emergence application of pendimethalin and speeded crabgrass development. The result was ≈10% increase in crabgrass by fall, and a similar decrease in percent Kentucky bluegrass as a component of the mixtures.

In summary, our results support earlier reports by Hunt and Dunn (1993) and Hsiang et al. (1997) that TF as a high percentage of the seeding mixture will remain competitive after several years with KB in established turf. PR as a low percentage of the seeding mixture will eventually dominate both TF and KB in mixtures regardless of management. Disease influenced turfgrass quality and, on occasion, the advantage of mixing species for disease resistance was apparent.

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