Tolerance of Selected Bluegrass and Fescue Taxa to Simulated Human Foot Traffic[1]

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Abstract

Cultivars of *Poa pratensis* L., *Festuca rubra* L., *subsp rubra*, and *Festuca arundinaceae* Schreb. were subjected to simulated foot traffic and three irrigation regimes. Soil compaction was evaluated by soil bulk density measurements.

Clipping yields of 16 bluegrass species and cultivars increased with increasing soil moisture. Highest yielding bluegrass cultivars were those with either upright growth habit or rapid vertical growth. The conclusion is drawn that, unless evaluated upon the percent yield change, clipping weights are not an accurate method of assessing trampling resistance of certain strongly rhizomatous, prostrate growing cultivars of Kentucky bluegrass during moderate, continuous trampling. Under the experimental conditions of this study, *Poa pratensis* L cultivars 'Merion', 'Newport', and 'Windsor' appeared to have greatest resistance to trampling; *Poa ampla* and *Poa trivialis* L. having least trample resistance.

Clipping yields of seven cultivars of *F. rubra* also increased in most cases with increasing irrigation level. Significant yield differences, assumed to represent growth rate differences, occurred among cultivars. Interactions between cultivar and trample level were taken as measures of differential wear tolerance. *Festuca rubra* L. subsp. *rubra* 'Pennlawn' was significantly higher in trample resistance than all others. *F. ovina* L. KO-16 had better apparent trample resistance than others which had equal resistance to trampling.

Festuca arundinaceae 'Goars' was observed to have superior trample resistance to the others studied which were equal. With a single exception, clipping yields of tall fescue decreased with decrease in irrigation levels.

Index words: *Poa pratensis* L., *Poa compressa* L., *Poa ampla* Merr., *Poa trivialis* L., *Festuca rubra* L. subsp *rubra*, *F. rubra* L. subsp. *commutata* Gaud.-Beaup., *Festuca ovina* L. KO-16, *Festuca arundinaceae* Schreber, oven dry clipping yields, irrigation levels

Introduction

Resistance to abrasion has been studied by turf researchers for a number of years. Genera or species (1, 2, 3, 11, 12, 14, 15, 17, 19), as well as mixtures of turfgrasses (5, 12) have been studied.

The literature yields little insight into the interaction between foot abrasion and irrigation levels. Klecka (6) reported *Lolium perenne, Poa pratensis, Agrostis canina,* and *Trifolium repens* to have greatest resistance to trampling by domestic animals. The effects of foot traffic on golf turf were reported by Ferguson (4).

Younger (19), using a spiked roller trampler first described by Perry (13), showed wear resistance of several grasses to be, in declining order, *Festuca arundinaceae* 'Alta', *Poa pratensis* 'Merion', *Festuca rubra* 'Illahee', *Poa pratensis, Lolium perenne, Agrostis palustris* 'Seaside', *Agrostis tenuis* 'Astoria', and 'Highland'.

Lunt (9) concluded that nitrogen applied after, but not before, wear had occurred, greatly enhanced the recovery rate, especially on nitrogen-deficient turfs.

Early turfgrass abrasion studies were designed to measure resistance to continuous wear until a predetermined "end point" was reached. Wood and Law (18) employed a somewhat different period of wear by operating a mechanical trampler over plots of 10 *Poa pratensis* cultivars for 22 consecutive days of a 35-day study period. Fifty trips (each trip equivalent to 5.6 walking men) were made per day. Visual ratings, taken before, at the end, and 10 and 20 days after trampling showed *Poa pratensis* cultivars 'Merion' and 'Nugget' to have excellent wear resistance; 'Sodco', 'Windsor', 'Pennstar', and 'Fylking' good; 'Cougar' and 'Newport' fair; and 'Delta' and 'South Dakota Certified' poor.

Under campground conditions LaPage (7) found that native *Festuca* decreased over three seasons, while *Agrostis* and *Poa* increased. During the first year, the fescue population declined only slightly. Controlled environmental studies by Shearman and Beard (15), showed *Festuca rubra* subsp. *commutata* Gaud.-Beaup. ('Cascade' Chewings Fescue) and *Festuca rubra* L. subsp. *rubra* ('Pennlawn' red rescue), to contain large quantities of lignocellulose, cellulose, hemicellulose, and lignin. Interspecies wear resistance was not directly correlated with these constituents on a gram dry weight basis but did correlate on a per unit area basis.

In related studies, Shearman and Beard (16) also showed no significant correlations between wear tolerance and such characteristics as shoot density, load bearing capacity, leaf tensile strength, percent moisture, and percent relative turgidity, and verdure. However, 'Pennlawn' red fescue resisted abrasion treatment from wheel and sled abrasion devices better than 'Casade' chewings fescue when evaluated upon turf quality per unit area (verdure) remaining after treatment (14). 'Pennlawn' red fescue was less wear resistant than 'Manhattan' perennial ryegrass, 'Kentucky 31' tall fescue, and 'Merion' Kentucky bluegrass. Only roughstalk bluegrass was less wear resistant than 'Cascade' chewings fescue.

Younger (19) observed that 'Alta' tall fescue was more resistant than certain other cool season grasses to abrasion from scuffing feet or spiked rollers. In combination with

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common Kentucky bluegrass, tall fescue also had greatest abrasion resistance (20). However, it ranked second to a mixture containing perennial ryegrass, common Kentucky bluegrass, and Astoria bentgrass when subjected to scuffing feet.

Shearman and Beard (16) associated wear resistance with the amount of cell constituents in tall fescue. As noted with fine fescues they showed a direct relationship between amount of cell wall constituents, expressed as mg/dm^2, with wear tolerance.

In vehicular wear resistance studies with *Poa pratensis* L., *Poa trivialis* L., *Festuca ovina* L., *Festuca ovina duriuscula* (L.) Koch (= *F. longifolia* Thuillier), *Festuca arundinaceae* Schreb., *Agrostis alba* L. (= *A. gigantea* Roth), *Bromus inermis* Leyss, *Phleum pratense* L., and *Dactylis glomerata* L., the first five species listed were, as a group, more resistant to wear than the others (11).

The present study was designed to examine turfgrass response to a wear cycle that allowed for continuous recuperation from trampling while being grown at three irrigation levels. Under park or golf fairway conditions trampling is moderate and distributed over a long wear period rather than being abraded to some "end point" as done in some previous studies (19, 20).

Materials and Methods

Species of *Poa* and *Festuca* and cultivars of fine fescue (*Festuca rubra* L.), tall fescue (*Festuca arundinaceae* Schreber), and Kentucky bluegrass (*Poa pratensis* L.) were seeded, at Bozeman, into a Huffine silt-loam Argic Cryoborolls soil on a level area in mid-August, 1973. For each species group, the experimental design was a split-plot with two replications per treatment. Plots were initially 0.91 × 1.8 m (3 × 6 ft), but were reduced in size to 0.91 × 1.2 m (3 × 4 ft) to accommodate plot equipment. Three irrigation treatments were randomly assigned to main plots. Plots were maintained at 20%, 75%, and 100% field capacity, as indicated by moisture blocks[3] buried at 15 and 30 cm (6-12 in) depth. Water potential calculations at ⅓, 2, 8, and 15 bars indicated that, at a moisture block reading of 20%, water potential in this soil was approximately 8 bars. When moisture at 30 cm (12 in) reached the desired level, irrigation was applied to bring the soil to field capacity.

Cultivars of each species were assigned at random to subplots. Seeding rates of fine fescue, tall fescue, and bluegrass cultivars were 86.0, 153.0, and 49.0 kg/ha (76.0, 131.0, 43.6 lb/A), respectively.

Grasses were trampled by passing a commercially manufactured 56 cm (22 in) wide power turf roller[4] fitted with nine "feet" over plots. Each "foot" consisted of a 3.2 mm (0.12 in) backing plate with a sole made from 9.5 mm (0.37 in) thick rubberized conveyor belt attached. Each "foot" had a surface area of 306.7 cm^2 (120 in^2) and created a pressure of 249.4 g/cm^2 (1.40 lb/in^2) on the turf surface and simulated a human weight of a 76.5 kg (170 lb). Trampling intensity was maintained at 10 passes every other day from June 10 to September 1974 and 1975. The response to trampling was estimated by measuring the regrowth of cultivars following periodic clipping throughout the season.

Plots were fertilized annually at 195 kg actual N/ha (172 lbs actual N/acre), applied May, Aug., and Sept. at 73.11, 48, 74, and 73.11 actual N/ha (64.5, 43.0, and 64.5 actual N/acre), respectively. Cultivars were clipped to a height of 3.5 cm (1.4 in) at 7 to 10-day intervals.

Results and Discussion

Tests on nine samples each from un-trampled soil at the 2.54 to 5.08 cm (1-2 in) depth, un-trampled soil at the 5.08 to 10.16 cm (2-4 in) depth, trampled soil at the 2.54 to 5.08 cm (1-2 in) depth, and trampled soil from the 5.08 to 10.16 cm (2-4 in) depth resulted in soil bulk density values of 1.20 gm/cc, 1.19 gm/cc, 1.26 gm/cc, and 1.23 gm/cc, respectively. Coefficients of variation for these values were at or below 4%.

Kentucky bluegrass: Clipping yields of all Kentucky bluegrass cultivars were increased in proportion to the amount of moisture maintained in soil (Table 1). There were no cultivar x irrigation interactions. Maintaining soil moisture at near field capacity was optimum for growth of bluegrass.

Trampling did not affect yield of bluegrasses in 1974 but decreased yield in 1975 over all irrigation levels. This suggests in addition to wear, an accumulative effect due to the observed increase in soil bulk density over the 2-year period. Such an increase in soil bulk density, due to compaction, and the associated reduction in clipping yield has also been reported by others (1, 2, 3, 17).

Untrampled plot yield differences (Table 2) appeared to reflect the vertical growth rates and/or the growth habit of the individual turfgrass. Data analysis based upon trampled plots seemed to eclipse certain expected yield differences

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Table 1. Mean seasonal clipping yields (gm/plot) for Kentucky bluegrass cultivars maintained at two levels of simulated foot traffic and three irrigation regimes. Values represent means for five harvests in 1974 and six harvests in 1975.

Level of trampling	Irrigation Regime % Field Capacity		
	100	75	20
		1974	
Untrampled	42.6 a[z]	35.1 b	24.7 c
Trampled	38.2 a	39.9 a	25.3 b
		1975	
Untrampled	140.3 a	86.6 b	53.9 c
Trampled	91.1 a	76.3 b	37.9 c

[z]Values followed by like letters within years, columns, and rows for irrigation are not significant at the 5% confidence level using Duncan's multiple range test.

Table 2. Mean seasonal clipping yields for 16 *Poa* taxa subjected to simulated foot trampling during two seasons. Means derived from six harvest dates.

Bluegrasses	Yield (gms/plot)		% Change
	Untrampled	Trampled	(Untrampled - Trampled)
'Cougar'	71.9	49.1	31.7 bc[z]
'Park'	102.6	80.0	22.0 b
'Delta'	117.6	90.7	22.9 b
'Merion'	64.9	58.5	9.9 a
'Newport'	92.8	83.4	10.1 a
'Prato'	90.1	71.8	20.0 b
'Flyking'	102.8	81.7	20.5 b
'Pennstar'	102.0	65.0	36.3 bc
'Primo'	92.1	78.2	15.1 b
'Windsor'	54.8	49.4	9.8 a
'Troy'	118.4	73.2	38.2 bc
NK 2591	97.2	65.4	32.7 bc
NK 2598	88.0	57.0	35.2 bc
Poa compressa	82.1	48.8	40.6 d
Poa ampla	138.3	75.1	46.0 d
Poa trivialis	97.8	73.3	25.1 b

[z]Values followed by like letters are not significant at the 5% confidence level using at least squares analysis.

due to trampling alone. Such *Poa pratensis* cultivars as 'Merion' and 'Windsor' yielded significantly less than *Poa ampla* Merr. or *Poa pratensis* L. 'Troy' during the second season. The latter two are of upright habit and yielded the highest.

When trampling was assessed using the difference between untrampled and trampled plots and expressed as a percentage, a better picture of trample by cultivar interaction was evident (Table 2). This appeared to eliminate yield differences due to growth rate or growth habit. 'Merion', 'Newport', and 'Windsor' yields were least affected by trampling as measured by yield change after trampling. Conversely, *Poa ampla* and *Poa trivialis* suffered the greatest reduction in yield. All others had yield differences that were not significantly different.

Many of the lower growing species and cultivars such as *Poa pratensis* L. 'Merion' have shown superior wear resistance and recuperative potential in former studies (Youngner, 1961; Wood and Law, 1972). Results of this study, in general were in agreement with those observed by these authors.

Fine Fescue: In 1974, all seven fine leaf fescues tested produced equal amounts of clippings whether trampled or not trampled. Trampling reduced yields significantly in 1975 when considered across all irrigation levels (Table 3), but yield reduction was not uniform from cultivar to cultivar and resulted in significant cultivar-trample level interactions. Among the fine fescues, growth habit was less influential on trample resistance and *Festuca rubra* L. 'Pennlawn' and *Festuca ovina* L. KO-16 were least affected by trampling when yields among trampled plots were compared. When analyzed using percent change between untrampled and trampled plots (Table 4), 'Pennlawn' yields were significantly smaller than the other fescues and was assumed to have best trampled tolerance, followed by *Festuca ovina* L. KO-16. All others had equal resistance to continuous, moderate trampling.

Low irrigation levels in 1974 resulted in significantly lower yields compared to the moderate and high irrigation levels which produced equal clipping yields (Table 3). In 1975, yields declined in a linear fashion with decrease in irrigation rates.

Tall Fescue: The higher irrigation rates significantly increased clipping yields over lighter irrigation plots in 1974 when turfgrass was untrampled, but irrigation rates had no effect on yield when plots were trampled (Table 5). In 1975,

Table 3. Mean seasonal clipping yields (gm/plot) of seven fine fescue cultivars maintained at two levels of simulated foot traffic and three irrigation regimes during two seasons. Values represent means for five harvests in 1974 and six harvests in 1975.

Level of trampling	Irrigation Regime (% Field Capacity)		
	100	75	20
		1974	
Untrampled	36.7 a	34.8 a	21.5 b
Trampled	34.1 a[z]	37.6 a	22.3 b
		1975	
Untrampled	166.9 g	115.9 h	64.1 i
Trampled	125.7 g	91.8 h	51.8 i

[z]Values within a year and row for irrigation regime followed by like letters are not significant at the 5% confidence level using Duncan's multiple range test.

Table 4. **Clipping yields of seven fine fescues subjected to simulated foot trampling during 1975. Values expressed as mean yield per plot and as mean percent yield change between untrampled and trampled plots.**

Fescue	Yield (gms/plot)		% Change
	Untrampled	Trampled	(Untrampled - Trampled)
'Ruby'	161.7	112.4	30.5 c[z]
commutata	134.3	84.7	36.9 c
'Pennlawn'	132.0	128.8	2.4 a
'Illahee'	104.5	86.6	17.1 b
'Dawson'	101.3	76.5	24.5 c
KO-16	71.8	78.3	9.1 b
'Wintergreen'	71.7	50.6	29.4 c

[z]Values followed by like letters are not significant at the 5% confidence level using least squares analysis.

Table 5. **Mean seasonal clipping yields of four tall fescues maintained at two levels of simulated foot traffic and three irrigation regimes during two seasons. Yield values based upon five harvests in 1974 and six harvests in 1975.**

Level of trampling	Irrigation Regime (% Field Capacity)		
	100	75	20
		1974	
Untrampled	59.2 a[z]	47.3 ab	37.4 b
Trampled	37.6 a	46.3 a	34.0 a
		1975	
Untrampled	154.2 b	214.7 a	137.5 b
Trampled	233.0 a	145.4 b	100.5 b

[z]Values followed by like letters within years and irrigation regime are not significant at the 5% confidence level using Duncan's multiple range test.

highest yield occurred at moderate irrigation levels when turfgrass was untrampled, but under trampling, highest yields were observed at the highest irrigation level.

Yields of the four tall fescues were the same whether trampled or non-trampled in 1974. In 1975, when cultivars were compared using, yield differences between untrampled and trampled plots, 'Goars' had significantly less change in yield after trampling and was assumed to have greatest trampling resistance. All others had similar trample resistance.

Effective evaulation criteria to measure tolerance of grasses to wear and compaction is difficult to obtain. Common measurements used are percent verdure, density counts, and visual estimates. In this study, I attempted to evaluate wear tolerance of three species based upon clipping yields during a 2-year period, and by soil bulk density measurements. While clipping yields reflect only upward growth and not lateral spread, they do reflect the vigor of the plant.

Clipping yields were found, in this study, to be an effective criterion for evaluating trample resistance when cultivars were compared using percent change between untrampled and trampled yields. This appeared to eliminate yield differences due to growth habit or growth rate. Clipping yields after trampling seemed to better reflect differences in tolerance of fine fescues to traffic stress than it did with bluegrasses or tall fescues, and permitted selection of wear tolerant cultivars.

From these data, it is concluded that *Poa pratensis* L. cultivars, 'Merion', 'Newport' and 'Windsor' have the best trample resistance of those studied. *Festuca rubra* L. 'Pennlawn' exhibited the best trample resistance of the fine fescues, and *Festuca arundinaceae* L. 'Goars' had the best wear tolerance of the tall fescues. With a single exception (tall fescue) all grasses produced increasing yield with increase in irrigation levels. All clipping yields were nonsignificant in the first year for all grasses studied. The differences noted in 1975 were believed due to the observed cumulative effect of trampling on soil bulk density over the two year period.

Table 6. **Clipping yields of four tall fescues subjected to simulated foot trampling during 1975. Values expressed as mean yield per plot and as mean percent yield change between untrampled and trampled plots.**

Fescue	Yield (gms/plot)		% Change
	Untrampled	Trampled	(Untrampled - Trampled)
'Kentucky 31'	171.1	195.3	14.0 b[z]
'Alta'	158.9	147.5	7.2 b
'Fawn'	190.0	142.8	24.8 b
'Goars'	155.2	152.9	1.5 a

[z]Values followed by like letters are not significant at the 5% confidence level using least squares analysis.

Significance to the Nursery Industry

Studies such as this will be of greatest interest to members of the green industry who are involved in turfgrass production for use on recreational sites, whether propagated, on site, from seed or installed as sod. As irrigation water continues to become limited in certain areas of the country, the need exists for grasses capable of providing a durable playing surface while being maintained under limited quantities of water.

Results of this research indicated that *Poa pratensis* L. cultivars 'Merion', 'Newport', and 'Windsor' have the best trample resistance and among the fine fescues, *Festuca rubra* L. 'Pennlawn' has greatest resistance to trampling. 'Goars' has the greatest trample tolerance of the four *Festuca arundinaceae* L. cultivars studied.

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