Evaluation of Selected Fine-leaf Fescue Cultivars for Their Turfgrass Quality and Weed Suppressive Ability in Field Settings

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SUMMARY. A series of field studies were conducted from 1999 to 2005 in Ithaca, NY, at the Cornell Turfgrass Research Center as part of the National Turfgrass Evaluation Program (NTEP) to evaluate a collection of 78 fine-leaf fescue cultivars (*Festuca* spp.) for turfgrass quality, seedling vigor, and ability to inhibit the establishment of common annual and perennial weeds. Using these criteria, we evaluated the overall suitability of the cultivars for use in turfgrass settings, as well as their potential weed suppressive or allelopathic ability. The ability of fine-leaf fescue to displace weeds was visually evaluated by density-wise comparison, and several cultivars of the 78 studied consistently established well and provided good to very good suppression (greater than 70%) of common turf weeds when established at the same planting density. Other cultivars provided moderate (between 35% and 70%) to (< 30%) little weed suppression. Greater weed suppressivity is likely associated with the differential ability of fescue cultivars to establish rapidly and to form a dense canopy, as well as potential allelopathic interference. This study was conducted in conjunction with laboratory experiments that revealed that certain fine-leaf fescue cultivars produced phytotoxic root exudates that were released into the rhizosphere over time. Additional field studies conducted in Ithaca showed that cultivars Intrigue, Columbra, and Sandpiper were consistently more weed suppressive than the other fine-leaf fescues evaluated. Although our understanding of the dynamics of production and degradation of fine-leaf fescue root exudates in the rhizosphere is limited, recent field studies also suggest that allelopathic interference as well as the ability to rapidly establish influence subsequent weed infestation in fine-leaf fescue stands. From a more practical standpoint, certain fine-leaf fescue cultivars, including Intrigue, Columbra, Sandpiper, and Reliant II, could be recommended for use in low-maintenance turf settings in the northeastern United States due to their aesthetic appeal and their limited weed infestation in circumstances where herbicides are not applied.

Fescue is one of the largest genera of the grass tribe Poaceae (Clayton and Renvoize, 1986). Of the ≈100 fescue species used in the United States and Europe, six cool-season fine-leaf fescue species are commonly used as turfgrasses in temperate and subarctic climates (Turgeon, 1999). Extensively used for forage, turf, or conservation purposes, fescue species vary greatly in morphology, cytology, and growth habits. Fine-leaf fescue is a common turfgrass in northeastern U.S. lawns and turf, especially in shaded areas (Jauhar, 1993). The fine-leaf fescue group includes slender creeping fescue (*Festuca rubra* ssp. *trichophylla* or ssp. *littoralis*) and strong creeping fescues (*F. rubra* ssp. *rubra*), chewing's fescue (*F. rubra* ssp. *commutata*), hard fescue (*Festuca longifolia*), and sheep fescue (*Festuca ovina*).

Fine-leaf fescue breeders have recently developed genetically improved cultivars that possess tolerance to acidic and low-fertility soils, as well as moderate shade and full-sun conditions. Currently, there is increased interest by the United States and European turfgrass industry in the use of fine-leaf fescue for lawn and golf turf as well as low-maintenance turf settings. Fine-leaf fescue is especially useful for settings experiencing variable light conditions and poor soils, and in regions with temperate climates. In addition, fescue generally thrives in dry, infertile sites such as roadside settings (Ruemmele et al., 1995).

The presence of turfgrass in a landscape impacts the human lifestyle from a visual, functional, and recreational point of view. In the United States, there are currently greater than 12 million hectares of turfgrass, including lawns, parks, golf courses, sod farms, industrial and institutional grounds, and highway right-of ways. In New York State alone, over 3.4 million hectares have been established in turfgrass (Ropel et al., 2004). In all turf settings, especially lawn and roadside turf, weeds are a key pest problem. A substantial pesticide market (over $2 billion) currently exists for the control of weeds, insects, and diseases in private and commercial turfgrass settings in the United States. Although herbicides continue to be the predominant form of weed management in commercial turf settings, herbicide use in public and private landscapes is increasingly challenged by environmental and health concerns (Mortensen et al., 2000). Consequently, turfgrass stakeholders, including homeowners and turf managers, are seeking alternative weed

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Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
0.4047	acre(s)	ha	2.4711
0.0929	ft^2	m^2	10.7639
2.54	inch(es)	cm	0.3937
1.1209	lb/acre	kg·ha^{-1}	0.8922
62.5000	oz/lb	mg·g^{-1}	0.0160

management tools (Matteson, 1995). One preventive strategy to minimize weed infestation is the use of appropriate turf mixtures or cultivars that are well-adapted to a given setting. Weeds are much less likely to invade a well-managed turf in optimal condition, maintained with appropriate cultural practices including timely mowing, fertilization, and irrigation (Bertin and Weston, 2004).

Biological and organic approaches for weed management in turf have often not provided effective long-term control of turf weeds (Bertin and Weston, 2004). Although plant pathogenic organisms have been evaluated for selective control of turf weeds, few, if any, commercial biocontrol products for weed management are currently available. Evaluation of organic products for weed management in turf has shown that most products do not provide selective or cost-effective, long-term weed suppression. Weed removal by mulching, cultivation, flame-burning, and steaming can be used in landscapes, but is cost prohibitive and sometimes injurious to turf (Bertin and Weston, 2004; Weston, 1999). Organic products such as acetic acid or clove oil-based products will result in significant turf injury. Corn gluten meal can provide some initial pre-emergent weed suppression, but many studies, including our own, have shown inconsistent control (Bertin and Weston, 2004).

Over the last decade, the study of plant-plant interactions and the use of allelopathy and plant interference as a potential weed management tool has received increasing attention in the literature (Hoffman et al., 1996; Weston and Duke, 2003; Wu et al., 1999). The use of allelopathy for weed management relies upon the species-specific responses of a target weed to chronic, and/or sublethal doses of an allelochemical, which can be exuded or leached from nearby living plants or decomposing residues. Weed suppressive cover crops that have been successfully used to suppress annual weeds have included economically important cereals such as wheat (*Triticum aestivum*), oat (*Avena sativa*), rye (*Secale cereale*), barley (*Hordeum vulgare*), sorghum (*Sorghum bicolor*), and rice (*Oryza sativa*) (Putnam and Tang, 1986). Although recent studies on allelopathic crops have focused on these key species, many other weedy and crop species show the promise of allelopathic potential for the suppression of surrounding vegetation. However, few studies have been conducted to further evaluate the allelopathic potential of these additional species (Hoffman et al., 1996; Weston and Duke, 2003). Recent trials with weed suppressive ornamental groundcovers have shown that the ability to establish rapidly, produce large quantities of biomass, and reduce light availability at the soil surface by producing a dense canopy and allelopathic properties can all influence weed suppressive ability (Eom et al., 2005).

Previous field experiments have shown that fescue species can be strongly weed suppressive when used for erosion control in agronomic, orchard, and vineyard settings (Malik et al., 2000; McGourty and Christensen, 1998; Morgan and Boubaki, 1999). Most studies have focused on the weed suppressive effects of tall fescue (*Festuca arundinacea*), which was shown to be potentially allelopathic (Peters and Zam, 1981). Weston (1990) has also demonstrated that strong creeping fescue was highly weed suppressive when established as living mulch or as killed sod in no-tillage field experiments. Although information on the potential allelopathic effects of fescue species is limited and generally unavailable for fine-leaf fescue turf cultivars, it is likely that one could easily select for enhanced weed suppressivity, given the great diversity of fescue germplasm available (Weston, 1996, 2005; Weston and Duke, 2003).

The objectives of this study, therefore, were to evaluate turfgrass quality and weed suppressive ability of fine-leaf fescue cultivars over a 3-year period. Based on initial evaluations, a subset of fine-leaf fescue cultivars was further evaluated in additional field trials conducted over a 2-year period.

Materials and methods

The National Turfgrass Evaluation Program (NTEP) experiment. The NTEP is a program sponsored by the U.S. Department of Agriculture (USDA) that generates data comparing cultivar performance of various turfgrass species in multiple settings across North America. In 1998, an NTEP fine-leaf fescue trial was established at Cornell University's Turfgrass Research Center in Ithaca, NY. Soil type was an Arkport fine sandy loam (psamentic Hapludlafs, coarse loamy mixed mesic), with a pH of 5.9 and organic matter content of ≈3.2%. Fine-leaf fescue species evaluated included blue fescue (*Festuca glauca*), chewing's fescue, hard fescue, sheep fescue, strong creeping fescue, and slender creeping fescue (Table 1). Before seeding, the ground was prepared by the removal of existing vegetation with the nonselective herbicide glyphosate applied at a standard rate of 1 lb/acre a.i., followed by incorporation of the residue into the soil. On 2 June 1998, after further grading, the soil fumigant dazomet was applied at 360 lb/acre a.i. The soil was then tilled and rolled. Before seeding, 22 lb/acre starter fertilizer (18N–10.5P–9.9K) was applied to the seedbed. Plots (20 ft^2) were seeded by hand on 15 June 1998 at a rate of 120 lb/acre and were irrigated regularly for 7 d after seeding. Cultivar treatments were established within a randomized complete block design with three replications.

Plots were regularly irrigated to maintain surface moisture until turf reached 60% cover, at which time irrigation was reduced to allow surface drying, and a second application of fertilizer was applied. Vegetation was mowed using a reel mower when plants were 2 inches tall, and irrigation was applied to prevent dormancy. When plants reached 1 inch in height, nitrogen was applied at a rate of 22 lb/acre to simulate golf fairway turf conditions. From 1999 to 2001, plots were maintained without supplemental irrigation, fertilization, or weed management using standard cultural practices for mowing to simulate fairway turf where height was maintained at 0.75 inch.

Turfgrass was evaluated for quality, density, and color on a visual basis using a 1 to 9 scale, with 9 being outstanding or ideal turf and 1 representing dead or poor turf. A rating of 6 or above is considered acceptable. According to NTEP guidelines, turfgrass quality ratings reflect aesthetic and functional aspects of the turf. Quality ratings were based on a combination of color, density, uniformity, texture, and disease infestation or sensitivity to environmental stress. For example, a quality rating value of 5 could be given to a turf based on

Table 1. Turfgrass quality, seedling vigor, spring green-up, and summer density evaluations of 80 fine-leaf fescue cultivars in Ithaca, NY, established as required by the National Turfgrass Evaluation Program (NTEP) from 1998 to 2002. Data are averaged over years from 1999 through 2002.

Fine-leaf fescue cultivar	Fescue species	Turfgrass quality (1–9 scale)[z]	Seedling vigor (1–9 scale)[y]	Spring green-up (1–9 scale)[x]	Summer density (1–9 scale)[w]
ASC 172	Strong creeping	4.5	4.3	6.7	7.3
Bighorn	Hard	4.9	4.3	6.5	6.7
Osprey	Hard	5.3	4.3	6.0	6.7
Berkshire (4001)	hard	5.7	4.7	5.8	7.3
MB-82	Hard	5.1	4.7	6.3	6.7
Pick FF A-97	Hard	5.3	4.7	6.0	7.0
PST-4HM	Hard	5.3	4.7	6.3	7.0
Rescue 911	Hard	5.2	4.7	6.7	7.0
ABT-HF-4	Hard	5.3	5.0	6.5	7.3
PST-4MB	Blue hard	5.4	5.0	6.2	6.7
Scaldis	Hard	5.1	5.0	6.3	7.0
SR 3200	Blue	4.8	5.0	6.8	6.3
ABT-HF-2	Hard	5.5	5.3	6.0	7.0
ASC 082	Strong creeping	4.9	5.3	6.2	7.0
Attila E	Hard	5.0	5.3	6.3	6.7
Banner III	Chewing's	5.2	5.3	6.8	7.0
Heron	Hard	5.2	5.3	6.7	7.0
Nordic (E)	Hard	5.4	5.3	5.8	6.7
Oxford	Hard	5.6	5.3	6.7	6.7
PST-4FR	Strong creeping	5.2	5.3	6.7	7.0
Reliant II	Hard	5.3	5.3	6.3	6.7
Scaldis II (AHF 008)	Hard	5.1	5.3	6.0	7.0
Shadow II	Chewing's	5.5	5.3	6.3	6.7
SRX 3961	Hard	5.6	5.3	6.2	7.0
ABT-CR-2	Strong creeping	5.4	5.7	6.2	6.7
ABT-HF-3	Hard	5.3	5.7	6.2	6.7
ACF 083	Chewing's	5.1	5.7	6.0	6.3
Ambassador	Chewing's	5.7	5.7	7.0	7.3
Ambrose (ABT-CHW-3)	Chewing's	5.7	5.7	7.0	7.0
BAR CHF 8 FUS2	Chewing's	5.3	5.7	6.0	6.7
Chariot (CIS Fl 12)	Hard	5.5	5.7	6.3	6.7
Defiant	Hard	5.1	5.7	6.5	7.0
Eureka II (CIS Fl 11)	Hard	5.4	5.7	6.2	6.7
Hardtop (BAR HF 8 FUS)	Hard	5.5	5.7	6.0	6.3
Magic	Chewing's	5.4	5.7	6.0	7.3
Minotaur	Hard	5.3	5.7	6.3	7.0
Quatro	Sheep	5.0	5.7	6.3	6.7
Shademark	Strong creeping	4.8	5.7	5.7	7.3
SR 5210 (SRX 52LAV)	Strong creeping	5.1	5.7	6.0	7
Stonehenge (AHF 009)	Hard	5.4	5.7	6.7	7.0
Viking (ABT-HF1)	Hard	5.8	5.7	6.5	7.0
ABT-CHW-1	Chewing's	5.4	6.0	6.0	7.0
ABT-CHW-2	Chewing's	5.7	6.0	6.5	7.3
ASR 049	Slender creeping	5.0	6.0	6.2	6.7
BAR SCF 8 FUS3	Slender creeping	5.1	6.0	6.3	6.7
Bargena III (BAR CF 8 FUS1)	Strong creeping	5.1	6.0	6.5	6.7
Brittany	Chewing's	5.3	6.0	6.7	7.0
Common creeping red	Strong creeping	4.3	6.0	6.0	7.0
Dawson E+	Slender creeping	4.8	6.0	5.5	6.7
DGSC 94	Strong creeping	5.0	6.0	6.3	7
Discovery	Hard	5.3	6.0	6.5	6.7
Inverness (PST-47TCR)	Strong creeping	5.1	6.0	6.5	7.0
Jasper II	Strong creeping	5.8	6.0	6.5	7.0
Longfellow II	Chewing's	5.9	6.0	6.2	7.0
MB-63	Chewing's	5.3	6.0	5.8	7.0
Pick Frc A-93	Chewing's	5.5	6.0	6.3	7.0

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Table 1. (*Continued*) Turfgrass quality, seedling vigor, spring green-up, and summer density evaluations of 80 fine-leaf fescue cultivars in Ithaca, NY, established as required by the National Turfgrass Evaluation Program (NTEP) from 1998 to 2002. Data are averaged over years from 1999 through 2002.

Fine-leaf fescue cultivar	Fescue species	Turfgrass quality (1–9 scale)[z]	Seedling vigor (1–9 scale)[y]	Spring green-up (1–9 scale)[x]	Summer density (1–9 scale)[w]
Rose (ASC 087)	Strong creeping	4.8	6.0	5.8	6.7
Shademaster II	Strong creeping	5.1	6.0	5.8	7.0
Silhouette (Pick Frc 4–92)	Chewing's	5.3	6.0	6.5	7.0
SR 5100	Chewing's	5.4	6.0	6.0	6.7
Tiffany	Chewing's	5.3	6.0	6.2	6.7
Treazure (E)	Chewing's	5.6	6.0	6.2	8.0
Wrigley (ACF 092)	Chewing's	5.3	6.0	6.0	7.0
ABT-CR-3	Strong creeping	5.6	6.3	6.2	7.0
Bridgeport	Chewing's	5.3	6.3	5.8	7.0
Cindy Lou (CIS Frr 7)	Strong creeping	5.7	6.3	6.3	6.7
Culombra	Chewing's	5.4	6.3	6.2	7.0
Florentine	Strong creeping	5.2	6.3	6.3	7.0
Intrigue	Chewing's	5.7	6.3	7.0	6.7
Jamestown II	Chewing's	5.1	6.3	5.5	7.0
Navigator (CIS Frr 5)	Strong creeping	5.6	6.3	5.7	7.0
Pathfinder	Strong creeping	5.3	6.3	6.0	7.0
Seabreeze	Slender creeping	5.0	6.3	5.5	7.3
Aberdeen (PST-EFL)	Strong creeping	5.5	6.7	6.0	7.0
Sandpiper	Chewing's	5.2	6.7	5.2	7.3
SRX 52961	Strong creeping	5.7	6.7	6.0	6.3
Boreal	Strong creeping	4.4	7.0	5.5	7.0
Salsa	Strong creeping	5.0	7.0	5.5	7.7
SR 6000	Hard	3.7	7.0	6.2	6.0
LSD (0.05)[v]		0.2	0.9	1.0	0.8
Coefficient of variation		10.7	9.9	10	7.3F

[z]1 = poor or dead turf, 9 = outstanding or ideal.
[y]9 = maximum vigor; data were taken for seedling vigor only in 1999.
[x]1 = straw brown in color, 9 = completely green in color.
[w]9 = maximum density; density ratings were collected in the summer.
[v]Fisher's protected least significant difference at the 5% significance level.

overall color and density, while another may receive the same value of 5 due to disease incidence and its impact on turfgrass density. Spring green-up evaluation was rated separately and was based on a visual rating performed during the 1999 growing season, with 9 representing actively growing dark green turf and 1 representing dormant turf. Evaluations for true color type are best made when the turf is actively growing and not under stress. Therefore, chlorosis and browning from necrosis due to disease were not considered as a part of the genotypic color evaluation.

Data on seedling vigor and spring green-up were obtained only in 1999, with a visual rating taken 90 d after seeding. Seedling vigor, a visual estimate of groundcover, and plant height that reflects the relative speed by which a cultivar develops into a mature sod, was also rated on a visual 1 to 9 scale, with 9 indicating maximum vigor. Weed suppressive ability was determined visually on a monthly basis by the same observer from July to Oct. 1999 and 2001, and from June to Oct. 2000, using a percentage scale where 0% denoted no weed suppression and 100% represented a weed-free plot. We arbitrarily classified the fescue based on their ability to suppress weeds with the following scale: strong (>70% suppression), moderate (between 30% and 50% suppression), and weak (<30% suppression). Data presented are the average of three replications. Mean separations were performed using Fisher's protected least significant difference (LSD) at the 5% significance level.

Multiple location experiment. Cultivars with consistently high or low weed suppression ratings from the previous experiment were selected for further evaluation in separate locations across New York State. A 2-year field study was conducted at the Long Island Horticultural Research and Extension Center, Riverhead, NY, in 2001 and at the Cornell University Turfgrass Research and Extension Center, Ithaca, NY, to evaluate the weed suppressive properties of selected fine-leaf fescue cultivars. Treatments for each species included weeding before fescue establishment (plots were weeded early in the season until the turf was well established) and no weeding (plots were not weeded during the experiment).

In Riverhead and Ithaca, fescue cultivars Attila, Boreal, Columbra, Intrigue, Jasper, Oxford, Reliant II, Rescue, Sandpiper, and Treazure were seeded at the standard rate of 130 lb/acre in Sept. 2000 into Haven sandy/silt Loam or Arkport fine sandy loam, respectively, and were fertilized only in Riverhead using standard rates (20 lb/acre) of 26N–1.3P–8.3K fertilizer. A phenoxy-based herbicide to control broadleaf weeds was applied at standard rates in Riverhead in Apr. 2001 and in late May in Ithaca for the weed to establishment plots only. The percentage of weed cover data were collected from all plots in May and August in both sites during the growing seasons of 2001 and 2002. Data presented are the average of four replicates. Mean separations were performed using LSD at the 5% significance level.

ITHACA TRIAL. A third study was performed only in Ithaca to further evaluate weed suppression provided by a diverse collection of fine fescue cultivars using a greater number of replications. In Sept. 2003, fine-leaf fescue cultivars were seeded at 130 lb/acre, and plots were subsequently rolled and irrigated. As before, weed suppression was evaluated based on visual ratings performed in August and October of 2004 and 2005. Cultivars evaluated included Oxford, Reliant II, Columbra, Rescue 911, Sandpiper, Intrigue, and several from Europe, including Wilma, Sylvia High, Christina, and RS158. Data presented are the average of 12 replicates. The percentage of weed cover data were subjected to analysis of variance with repeated measures. All data were analyzed using SAS procedure MIXED model (release 9.1; SAS Institute, Cary, NC). Mean separations were performed using Tukey's honestly significant difference (HSD) at the 5% significance level.

Results and discussion

NTEP experiment

TURFGRASS QUALITY. Fescue quality ratings from all NTEP trials carried out in North America from 1999 to 2002 were averaged and ranged between 3.7 and 5.9 on a 1 to 9 scale according to the NTEP rating recommendations. At the Ithaca site, ratings during this period also ranged between 3.8 and 5.8, suggesting that this location is adequate for fine-leaf fescue establishment when compared with other North American regions (Table 1). Our monthly ratings from 1999 to 2001 showed that turfgrass quality ranked higher in 1999 (between 4 and 6) than in 2000 and 2001 (between 2 and 4) (data not shown). Differences in turfgrass quality could be potentially associated with climate variation; 1999 was the third driest year in Ithaca, NY, since 1969, whereas precipitation levels in 2000 and 2001 were closer to the long term average (Cornell University, unpublished data). The fine- and coarse-leaf fescues are generally considered to be particularly drought tolerant (Turgeon, 1999). It is interesting to note that fescue establishment was not negatively impacted by the dry conditions encountered in 1999, suggesting that the cultivars evaluated were also well adapted to drought.

SEEDLING VIGOR. Seedling vigor ratings followed similar trends to those observed for turfgrass quality (Table 1). In general, cultivars with high vigor ratings also exhibited higher overall turfgrass quality. Vigor or rapid establishment, a trait fescue breeders often select for, appears to be important in influencing overall turfgrass quality, and may have influenced quality ratings even in 2000, 2 full years following turf establishment. Seedling vigor is also an important factor influencing weed infestation in turf, as a vigorous, well-established turf results in reduced weed establishment (Turgeon, 1999).

SPRING GREEN-UP. Spring green-up is a measure of the transition from winter dormancy to active spring growth. Aesthetic appeal is very important when considering cultivar selections for golf courses, lawns, and athletic fields. For the 78 cultivars evaluated, ratings varied between 5.2 and 7 on a 1 to 9 scale, with 1 being completely dormant or brown and 9 being completely green. Findings from this study suggest that the transition between winter dormancy and spring growth in Ithaca was considered average. Spring green-up evaluation is based on plot color, and color evaluation is one of the key visual assessments that account for turfgrass quality; a close relationship between turfgrass quality and color generally exists.

WEED SUPPRESSIVE ABILITY. We evaluated the long-term ability of fine-leaf fescue cultivars to suppress weeds over time. Weed suppressive ability (Table 2) was evaluated by comparing the percentage of fescue coverage within the plot to the percentage of weed infestation. The weeds encountered included common broadleaf turf weeds such as dandelion (*Taraxacum officinale*), broadleaf plantain (*Plantago major*), and white clover (*Trifolium repens*), as well as grasses, including large crabgrass (*Digitaria sanguinalis*) and smooth crabgrass (*Digitaria ischaemum*).

Because there were no significant differences in weed density between

Table 2. Evaluation of the weed suppressive ability of 80 fine-leaf fescue cultivars from the National Turfgrass Evaluation Program (NTEP) trial in Ithaca, NY, from 1999 to 2001.

Fine-leaf fescue cultivar	Weed suppressive ability (0–100 scale)[z]		
	1999	2000	2001
SR 3200	43	32	37
Minotaur	50	40	30
PST-4MB	60	64	61
ABT-CHW-1	47	78	80
ABT-CHW-2	53	58	55
ABT-CHW-3	40	62	60
ACF 083	80	68	72
ACF 092	43	84	79
Ambassador	57	60	62
Banner III	53	62	60
BAR CHF 8 FUS2	47	58	50
Bridgeport	77	62	60
Brittany	67	62	60
Columbra	37	68	66
Intrigue	53	54	60
Jamestown II	87	66	66
Longfellow II	77	76	75
Magic	53	72	80
MB-63	67	60	63
Pick Frc 4–92	57	66	61
Pick Frc A-93	60	70	72
PST-4HM	53	62	58
Sandpiper	87	78	80
Shadow II	53	52	55
SR 5100	80	76	78
Tiffany	63	56	60
Treazure (E)	60	72	70
4001	73	56	60
ABT-HF1	47	50	50
ABT-HF-2	60	52	55
ABT-HF-3	37	64	60
ABT-HF-4	57	60	60
AHF 008	53	54	55
AHF 009	57	26	10
BAR HF 8 FUS	57	60	60
Bighorn	50	50	60
Defiant	53	54	55
Discovery	50	54	55
Heron	43	40	50
ISI FI 11	60	44	50
ISI FI 12	47	48	50
MB-82	60	58	70
Nordic (E)	30	44	50
Osprey	60	58	60
Oxford	50	66	70
Pick FF A-97	80	62	70
Reliant II	57	48	60
Rescue 911	18	34	50
Scaldis	50	50	60
SRX 3961	63	30	50
Quatro	67	44	50

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Table 2. (*Continued*) Evaluation of the weed suppressive ability of 80 fine-leaf fescue cultivars from the National Turfgrass Evaluation Program (NTEP) trial in Ithaca, NY, from 1999 to 2001.

Fine-leaf fescue cultivar	Weed suppressive ability (0–100 scale)[z]		
	1999	2000	2001
ASR 049	43	54	50
Attila E	73	56	78
BAR SCF 8 FUS3	60	52	60
Dawson E+	57	54	60
Seabreeze	63	68	75
ABT-CR-2	82	68	75
ABT-CR-3	60	58	70
ASC 087	63	40	55
ASC 172	53	68	66
ASD 082	80	46	60
BAR CF 8 FUS1	47	66	70
Boreal	87	58	60
Common creeping red	57	60	55
DGSC 94	60	56	60
Florentine	47	56	55
ISI Frr 5	53	56	55
Jasper II	67	60	66
Pathfinder	33	70	80
PST-47TCR	57	76	80
PST-4FR	70	46	55
Salsa	73	78	80
Shademark	53	46	50
Shademaster II	73	84	79
SRX 52961	47	82	80
SRX 52LAV	67	76	70
PST-EFL	57	60	55
Scottish Links	35	26	20
SR 6000	47	28	18
LSD (0.05)[y]	11	9.2	10

[z]0 = no weed suppression, 100 = complete weed suppression. Rating values shown for each year represent the mean of three replicates and of two or three evaluations during the growing season from 1999 to 2001. Data were averaged over months of ratings collected during the growing season.
[y]Fisher's protected least significant difference at the 5% significance level.

the monthly ratings within the same year, we averaged weed density over time. A significant cultivar ($F = 2.44$, $P < 0.05$) by fine-leaf fescue subspecies interaction was noted for weed density. Among the 78 cultivars evaluated, 10 cultivars representing just two subspecies (chewing's fescues and strong creeping fescues) were strongly weed suppressive during 1999 to 2001, with more than 70% to 80% weed suppression.

Cultivars evaluated as most suppressive included the strong creeping fescue cultivars and chewing's fescue cultivars Sandpiper, Shademaster II, Intrigue, Longefellow II, Jamestown II, Salsa, ABT-CR2, ACF 083, PST47T, and SRX52LAV. In contrast, weed suppression was poor or unacceptable (greater than 60% weed cover) in plots seeded with the cultivars Rescue 911 (a hard fescue) and SR 3200 (a blue fescue). Other fine-leaf fescue cultivars were rated as intermediate for weed suppressive ability.

Successful fescue establishment appears to be affected by climatic conditions, given the variable responses obtained from 1999 to 2001. As described previously, fine-leaf fescue establishment in the plots was generally favored during the relatively dry year (1999), resulting in greater suppression of weeds. It is also clear that subspecies and cultivar, representing significant sources of genotypic variation among fescues, are also important factors influencing weed suppressivity over time.

Our laboratory research has shown that several of the fine-leaf fescue cultivars used in this study, specifically the chewing's fescues and strong creeping fescues, actively exude root-derived phytochemicals with potent bioherbicidal activity (Bertin et al., 2003). The isolation and identification of a single bioactive compound contained in the root exudates of a chewing's fescue, cultivar Intrigue, revealed an amino acid analog, *m*-tyrosine, that is strongly phytotoxic to numerous weedy dicots and monocots encountered in turf settings (Bertin et al., 2007). We speculate that differences observed in weed suppressive ability among fine fescues are associated not only with their ability to establish quickly and maintain a dense canopy, but also the potential production of allelochemicals such as m-tyrosine that actively suppresses competing species. Currently, the dynamics of allelochemical production and release into the soil rhizosphere are not well understood. However, we have observed that the seedlings of chewing's fescue, cultivar Intrigue, produce up to 3-fold higher concentrations of the inhibitor, *m*-tyrosine, when under drought conditions in comparison with other fine-leaf fescues (Bertin et al., 2003). The evaluation of weed suppressive ability of fine-leaf fescues in several different geographic regions and under varying edaphic conditions is required to clearly determine the importance of cultivar and subspecies upon weed suppression.

Generally, correlations observed between fine-leaf fescue weed suppressive ability and quality were not consistent; specifically, certain cultivars with high turfgrass quality ratings (e.g., AHF 009 and ABT-HF-1) exhibited low weed suppressive ability, whereas cultivars such as Sandpiper with lower turfgrass quality ratings provided strong suppression of weeds. Because turfgrass quality was evaluated only in year 1 as a measure of color and texture, it is not surprising that this individual rating did not closely correlate with observed long-term growth or weed suppressive characteristics. Further long-term studies are required to address the correlation between turf quality and weed suppressive ability.

Turf color is a key characteristic in the evaluation of NTEP quality ratings. As a result, NTEP quality ratings have sometimes been considered to be strongly biased. However, in our study, we expected greater positive correlation between quality ratings and weed suppressive ability, as weed presence usually influences turf color and uniformity and therefore the aesthetic appeal or overall appearance of the turf. We also expected greater positive correlation between seedling vigor and weed suppressive ability because one of our hypotheses is that a more vigorous turf will initially be able to establish better and to out-compete weeds in a more effective manner than less competitive seedlings. This observation leads us to conclude that there is perhaps another factor involved in the ability to suppress weed infestation by several fine-leaf fescue species and cultivars, such as the release of phytotoxic compounds into the environment by certain fescues.

Multiple location experiment

Given that different individuals performed visual ratings in Ithaca versus Long Island, we did not directly compare the actual percentages of weed coverage data, but the trends observed in both locations during the 2 years of this study. Several fine-leaf fescue cultivars were selected for this multilocation trial based on the results of the NTEP trial in Ithaca; specifically, we included cultivars Sandpiper, Columbra, Reliant, and Intrigue, which were noted to successfully suppress weeds, whereas cultivars Oxford, Attila, Jasper, Rescue 911, and Treazure exhibited a lower or intermediate weed suppressive ability during 1999 to 2001.

Edaphic factors differed substantially between the Ithaca and Riverhead sites and may explain some of the variation in responses observed among these sites. For example, the cultivar Treazure showed the highest weed densities in Riverhead, whereas weed densities for other cultivars were not significantly different over the 2-year study period (Fig. 1). In 2002, a general reduction in weed abundance was observed for all cultivars in Riverhead; weed infestation levels typically decreased by up to 3-fold in 2002 in comparison with 2001. In Ithaca, no individual cultivar stood out in its weed suppressive ability in 2001 (Fig. 2) (i.e., all cultivars exhibited 50%–70% turf coverage with only moderate weed infestation observed). In 2002, however, weed infestation was also substantially lower for all cultivars evaluated (15%–39%). In comparison with 2001 ratings, these findings suggest that the ability of fine-leaf fescue cultivars to displace weeds in a field setting is dependent on the climatic and edaphic site conditions as well as time of establishment. Not surprisingly, we observed that well-established turfgrass stands exhibited greater weed suppression in landscape settings. Over a 2-year period in Ithaca and Riverhead, a strong decrease in weed infestation levels was observed (Fig. 1), with large crabgrass being the principal weed species present in both years.

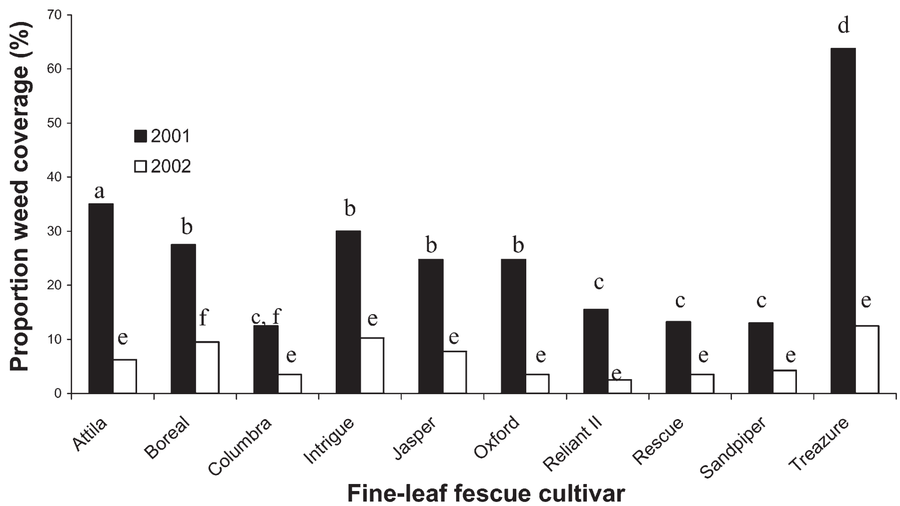

Fig. 1. Percentage of weed cover in fine-leaf fescue cultivars evaluated in 2002 and 2003 in Riverhead, NY. Values for each year represent the mean of evaluations collected during each growing season. Letters above bars represent statistically significant differences as detected by Fisher's protected least significant difference test at the 5% significance level [LSD (0.05) = 3.8%].

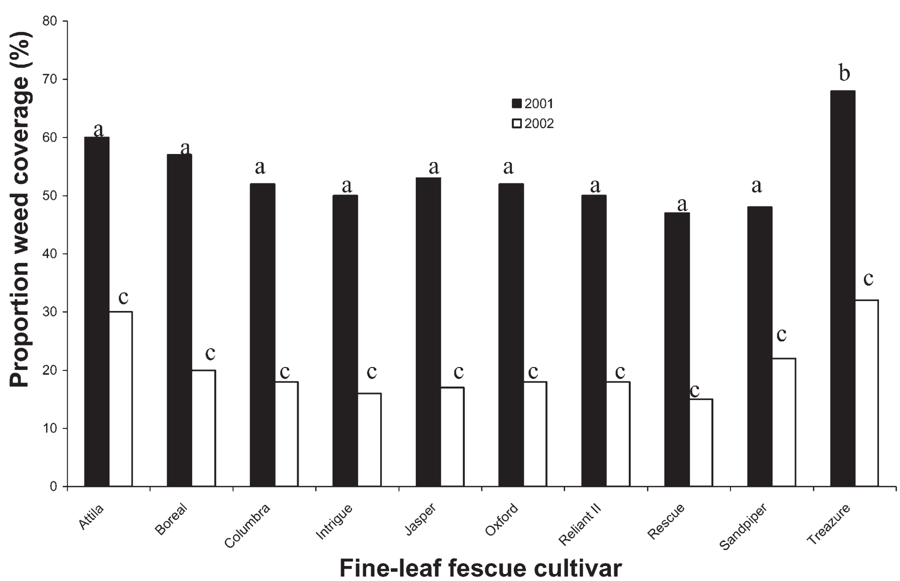

Fig. 2. Percentage of weed cover in fine-leaf fescue cultivars evaluated in 2002 and 2003 in Ithaca, NY. Values for each year represent the mean of evaluations collected during each growing season. Letters above bars represent statistically significant differences as detected by Fisher's protected least significant difference test at the 5% significance level [LSD (0.05) = 5%].

Ithaca trial

In an expanded trial conducted at the Ithaca site using a greater number of replications to detect cultivar differences, the chewing's fescue cultivars Intrigue, Columbra, and Sandpiper clearly provided the greatest weed suppression in 2004 and 2005 (Table 3). Of the 10 cultivars evaluated, two main groupings were observed: those cultivars that provided greater than 85% coverage or less than 15% weed infestation (Intrigue, Columbra, Sandpiper, and Reliant II) and those cultivars that provided less than 75% coverage of plots or greater than 25% to 30% infestation (Sylvia High, and RS158). This experiment confirmed earlier findings observed in the NTEP field trial in Ithaca as well as laboratory experiments (Bertin et al., 2003) that showed that certain cultivars possessed an enhanced ability to suppress weeds and good overall turf quality. Highly weed suppressive cultivars included chewing's fescue Intrigue, Columbra, Sandpiper, and, specifically in this experiment, the hard fescue cultivar Reliant II.

The same cultivars were also observed to be most inhibitory to weed seedling growth in several different bioassays conducted in the laboratory (Bertin et al., 2003). It is possible that the reduced weed suppressive ability observed in the two

Table 3. Percentage of cover data collected from Aug. 2004 to June 2005 of various fine-leaf fescue cultivars established in Ithaca, NY, in 2003.

Fine-leaf fescue cultivar	Proportion weed coverage (%)		
	Aug. 2004	Oct. 2004	June 2005
Wilma	80.8[z] a[y]	84.2 ab	89.8 abc
Sylvia High	40.0 c	65.8 cd	70.3 d
Christina	80.8 a	83.3 ab	81.6 bc
RS158	57.5 b	67.5 cd	74.6 cd
Oxford	74.6 a	74.6 bcd	88.1 abc
Reliant II	82.1 a	86.3 ab	93.8 a
Columbra	87.1 a	88.2 ab	90.8 ab
Sunny Green	80.8 a	81.3 abc	81.0 bc
Rescue 911	77.1 a	81.3 abc	85.3 abc
Sandpiper	85 a	87.5 ab	89.8 abc
Intrigue	88.8 a	89.2 a	94.7 a
HSD[y]	15.31	14.41	10.14

[z]Values represent the mean of 12 replications for each cultivar.
[y]Letters within a column that are the same are not significantly different at the 5% level of significance according to the Tukey's honestly significant difference test (HSD).

European cultivars (RS158 and Sylvia High) in 2004 and 2005 was associated with their inability to adapt to warmer, continental growing conditions encountered in Ithaca compared with those of cooler conditions in Scandinavia, where they were judged to be exceptional performers.

Enhanced weed suppressive ability of fine-leaf fescue cultivars may be attributed to the innate ability of certain fescues to compete more efficiently with weeds. A well-established dense turf generally leads to lower weed densities and fewer weed management problems (Turgeon, 1999). Certain cultivars consistently produced dense, well-established stands within 12 to 18 months after seeding in New York locations. All fine-leaf fescues were generally more weed suppressive in their second and third growing seasons after establishment. This may be due to denser canopy formation, which results in greater weed suppression and competition with weed seedlings, as well as the potential ability of certain cultivars to release greater levels of allelochemicals when well established. Recent laboratory trials have shown that even 2-week-old chewing's fescue seedlings can produce ≈1 mg of root exudates per gram of fresh root weight when grown under soil-free conditions. This represents a significant output of secondary products through the root exudation process. However, we currently know little about the ability of well-established field-grown turf to produce and release root exudates into the rhizosphere.

Although turf density as well as the potential production of allelochemicals inhibitory to weed seedling germination and growth may vary with turf maturity, early suppression of weed growth and enhanced biomass production is clearly important in newly established stands due to competitive advantages allowing for reduced weed infestation during the critical period of turfgrass establishment. Fescues are known to be particularly slow to establish in comparison with other turfgrasses (Turgeon, 1999). Any evolutionary adaptation leading to enhanced competitiveness during the critical period of turf establishment, including enhanced growth rates or allelochemical production resulting in enhanced weed suppression, may lead to greater reproductive fitness over time. Our laboratory evaluations show that certain chewing's fescue and strong creeping fescue, as well as arizona fescue (*Festuca arizonica*), produce significant levels of potent phytoinhibitors from their living root systems (Bertin et al., 2007).

Results obtained from multiple field studies performed in several locations experiencing diverse environmental conditions indicate that certain chewing's fescues, strong creeping fescues, and hard fescues exhibited very marked weed-suppressive tendencies in field experiments. Because this weed-suppressive ability might be linked to the production of allelochemicals, we would recommend at this time that one considers the selection of a fine-leaf fescue within the subspecies chewing's fescues, strong creeping fescues, or creeping red fescues for production in the temperate northeast. In addition, certain hard fescues, which do not appear to produce the same exudates in terms of chemical constituents as the subspecies described above, may sometimes be better performers in terms of weed suppressive ability, as evidenced by the performance of Reliant II. Our research has shown that establishment at seeding rates of 130 lb/acre provides reasonable density and good stands within several months after planting. Additional laboratory studies would be helpful in determining whether hard fescue or less closely related fescues produce similar or unrelated phytotoxin(s) in their root exudates.

Because climate and soil properties are important factors influencing turf establishment, turf color and quality, and allelochemical release, it is very difficult to give broad spectrum recommendations in terms of which cultivar to select for use across North America. However, for areas with similar climate and similar soil characteristics as those encountered in Ithaca or Riverhead, NY, we would recommend consideration of cultivars Intrigue, Reliant II, Columbra, and Sandpiper, which consistently performed well in both locations. Additional long-term studies monitoring rate of biomass production, turf density, and potential allelochemical production over time in various field settings would be valuable in furthering our understanding of the factors contributing to differential weed suppression by certain fine-leaf fescue cultivars over time.

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