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TURFGRASS TRENDS

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AGRONOMY

Freeze-Stress Resistance

How freeze-stress resistance in perennial ryegrass relates to turfgrass performance

By J. S. Ebdon, Ph. D.

Each winter in New England and the northern United States, substantial turf losses occur due to injury from freezing temperatures. Turf injury and losses that result from freezing temperatures can have an economic and environmental impact on the functional quality and aesthetic value of turf areas. Turf loss results in increased weed pressure and herbicide cost, increased soil erosion, decreased use and, in the end, the need for costly and extensive re-establishment (Dipaola and Beard, 1992).

Turfgrass species and varieties vary considerably in their tolerance to freezing stress (Gusta et al., 1980). Perennial ryegrass (Lolium perenne L.) has been reported to have the poorest low temperature tolerance among cool-season turfgrass species (Beard, 1973). However, cultivars of perennial ryegrass can vary widely in their lethal killing temperatures (LT_{50}), ranging from -5 to -15 °C (Gusta et al., 1980).

Despite having poor low temperature tolerance, perennial ryegrass is still one of the most important and widely used species in the northern United States (Meyer and Funk, 1989; Watson et al., 1992). Its ability to establish quickly makes it a popular choice of turf managers for overseeding fairways, institutional grounds, parks, home lawns and in lawn care operations. It is expected that the popularity of perennial ryegrass will continue to increase in the northeast and elsewhere with the release of new and improved cultivars.

Turfgrass freezing stress

Turfgrass freezing stress occurs at 0 °C (32 °F) and colder temperatures. Injury to turfgrass due to freezing temperatures involves the formation of ice crystals in and around the cells of the regenerative region of the plant (Beard, 1973; Rossi, 1997). The regenerative region of a turfgrass plant, also known as the crown, is the region that includes the stem apex, the unelongated internodes and the lower nodes from which the adventitious roots are initiated (Hull, 2000). Since adventitious roots, lateral shoots (tillers, rhizomes, and stolons) and leaves all initiate from this region, the crown tissue is considered the most vital portion of a turfgrass plant (Beard, 1973; Hull, 2000).

If temperatures drop quickly, intracellular freezing will occur in tissues, especially those having high tissue hydration levels. The ice crystals cause a mechanical disruption to the cell membranes that result in death of the tissue. The lysis of cells with the release of cell contents from this type of injury can be measured in the laboratory using electrolyte leakage methods. This approach is effective in identifying injury at the cellular level.

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An alternative approach effective in assessing actual survival from freezing injury is to use whole plants and freeze-shock recovery methods.

Ability of turfgrass to survive freezing stress is a function of the severity of the injury and its location within the crown.

The ability of turfgrass to survive freezing stress is a function of the severity and location of the injury within the crown. If a sufficient number of cells within the crown of the turfgrass plant are injured, the grass may not recover. Whole-plant regrowth and recovery studies following exposure of plant samples to low-temperature stress is the most effective means of evaluating freezing stress tolerance and is often used to assess low temperature survival. Whole-plant survival of bunch-type grasses such as perennial ryegrass depends on the production of tillers.

Improved survival of hardened perennial ryegrass depends on the ability to establish viable regrowth from lateral tiller buds (Eagles et al., 1993).

It has been reported that the lower portion of annual bluegrass crowns are more likely to be injured, due to freezing stress, than the upper portion (Beard and Olien, 1963; Beard, 1973). The lower apical meristem responsible for root initiation can be injured more easily than the upper apical meristem (Beard, 1973; Olien and Marchetti, 1976). This injury can be exacerbated by desiccation in early spring when transpiration resulting from warming temperatures and resumed growth exceeds the water uptake capability of the injured roots.

For some grass species, survival to freezing stress can be limited by the tolerance of a relatively small number of cells in the basal region of the crown (transition zone between the root and shoot), rather than the apical meristem (shoot apices and lateral buds) (Shibata and Shimada, 1986; Tanino and McKersie, 1985). Different regions of the crown are killed at different temperatures (Eagles et al., 1993) because of differential hardening within the crown itself. Recovery is still possible providing critical crown regions important in regrowth remain viable.

Freeze-stress tolerance, quality

Freezing stress is a major factor limiting the adaptation of turfgrass to northern climates (Beard, 1973). For species with marginal low-temperature hardiness, such as perennial ryegrass, this may be an especially important limitation to growth, function and overall quality of the turf.

Turfgrass quality is a subjective measurement of aesthetic appeal and functional value, and includes components such as color, shoot density, uniformity and texture (Turgeon, 1980). Therefore, shoot density (tiller density), which is an important component of turfgrass quality, is directly affected by direct low-temperature kill.

In perennial ryegrass, whole-plant survival to freeze-stress temperatures depends on tiller production for regrowth. Superior tillering capacity could have a beneficial effect on the recovery from low-temperature stress because more tiller buds are available for regrowth, thus influencing winter survival. Superior turfgrass performers could have improved freeze-stress recovery and survival because of more profuse tillering compared to poor performers. Accordingly, there is a potential link between turfgrass quality and the capacity to recover from freeze-stress injury.

The goal of turfgrass managers is to select grasses that are well adapted to environmental stresses that limit turfgrass growth at their location. To that end, a study was initiated at the University of Massachusetts to compare the freezing-temperature thresholds for survival in cultivars of perennial ryegrass representing contrasting qualities. The study emphasized low-temperature tolerance and its relative contribution to turfgrass quality when targeting turfgrass to northern climates.

Plant material selection

The criteria for cultivar selection was based on the relative ranking (top and bottom cul-

The popularity of perennial ryegrass will continue to increase in the Northeast and elsewhere with the release of improved cultivars.

tivars) from the most recent (1997) National Turfgrass Evaluation Program (NTEP) field trial conducted at the Maine (Orono) location (the most northern NTEP location in New England) (USDA, 1997). Ten perennial ryegrass cultivars representing diverse quality types (5-high and 5-low ranking cultivars) were chosen (Table 1). Cultivars LRF-94-C8, Palmer III, Prelude III, Repell III and Top Hat represented high (superior) performers, and DSV NA 9401, DSV NA 9402, Linn, Pennfine and SR-4010 were selected to represent the low (poor) performing varieties.

The average January air temperature for Maine during the period from 1994 to 1998 (the corresponding NTEP evaluation period on which the cultivar selection was based) was -10.3 °C (+13.5 °F) (Table 2, NRCC report).

Air temperature is less important to crown survival than soil temperature since crowns are located near or below the soil surface and are protected by the warmer soil temperatures (Beard, 1973). The air temperature data summarized in Table 2 indicates, however, that the average temperature for January in Maine is within the lethal temperature range of –5 to –15 °C for some perennial ryegrass cultivars (Gusta et al., 1980). There was considerable range in January temperatures (and the potential for freezing-stress injury) between northern New England states (Maine, New Hampshire and Vermont) and southern New England (Massachusetts, Connecticut and Rhode Island).

Acclimation

Cultivars were established from seed and were sown (September 23, 1998) in 2-in. diameter by 7-in. deep pots filled with a commercial planting mix consisting of peat, perlite and vermiculite. Cultivars representing "LOW" and "HIGH" performance types were evaluated under two environments representing "Acclimated" and "Non-Acclimated" tissue.

On December 9, 1998, container plants were transferred following a 10-week establishment period in a heated greenhouse to the field and placed in a cold frame in a covered but open-ended polyhouse at the University of Massachusetts Turfgrass Research Farm in South Deerfield, MA. Containers were placed directly on the soil surface as close to each other as possible. The plants were kept in the cold frame for the remainder of the fall season into winter in order to simulate field acclimation (physiological hardening) conditions as closely as possible. Non-acclimated plants were kept in the heated greenhouse (70 °F) during the same period.

TABLE 1. RELATIVE RANKING AT THE MAINE-ORONO NTEP LOCATION

(1=highest, 96=lowest turfgrass quality ranking)

Cultivar	Rank
High-performance group	
LRF-94-C8	6.0
Palmer III	3.0
Prelude III	1.5
Repell III	1.5
Top Hat	4.0
Low-performance group	
DSV NA 9401	93.0
DSV NA 9402	89.5
Linn	95.5
Pennfine	94.5
SR-4010	95.5

Crown and root-zone temperatures were monitored. Figure 1 shows the mean daily soil temperature vs. the plant container media temperature at the surface and 2.5-cm (1-in.) into the soil/media. Note that the average surface temperature of the plant media (which is in intimate contact

TABLE 2. AVERAGE JANUARY AIR TEMPERATURE (°C) FROM 1994 THROUGH 1998 FOR THE NEW ENGLAND REGION. FROM THE NORTHEAST REGIONAL CLIMATE CENTER.

State	1994	1995	1996	1997	1998	Avg.
ME	-15.6*	-7.2	-10.3	-10.1	-8.1	-10.3
VT	-14.3	-4.2	-9.1	-8.5	-5.3	-8.3
NH	-12.6	-3.7	-7.4	-7.8	-4.8	-7.3
MA	-7.9	+0.1	-3.9	-3.4	-0.9	-3.2
CT	-7.5	+0.1	-4.1	-3.2	+0.3	-2.9
RI	-4.7	+2.1	-1.7	-1.2	+1.8	-0.7

* Lowest average temperature for January ever recorded.

with crown tissues) dropped to a low of -12.6 °C (+9.3 °F) by January 15, which is lower than the temperature threshold for survival (LT50) of some perennial ryegrass cultivars. Average soil temperatures were considerably warmer and less variable than container media.

Freeze-shock recovery (survival)

Freezing shock and subsequent recovery of plant material was evaluated by submitting container plants to a range of 11 decreasing treatment temperatures consisting of a non-frozen control (+5 °C), and 10 freeze-stress temperatures: -3, -5, -7, -9, -11, -13, -15,-17, -19, and -21 °C.

Treatment temperatures were applied using a programmable freezer. After temperature exposure, the plant material was removed from the freezer and assessed for survival as a percentage of viable-green shoots. Plant samples were planted in cell trays and placed in the greenhouse for a four-week recovery period.

Plants with any green surviving tissues or any new growth from even one shoot were counted as survivors. All others were considered as having been killed by the treatment temperature. The temperature at which 50% of the crown tissue survived based on regrowth recovery was determined statistically and expressed as LT50.

Effects of acclimation on low-temperature hardiness

Cold acclimation (hardiness) involves physiological changes within the plant. As fall soil temperatures approach 45 °F, turfgrass shoot growth slows and eventually stops. Carbohydrate levels increase and tissue (crown) hydration levels decrease, resulting in the tissue achieving maximum low-temperature hardiness (Beard, 1973; Levitt, 1980). A period of 3 to 4 weeks of average daily air and soil temperatures between 34 to 45 °F are optimum to harden cool-season turfgrass (Beard, 1973).

Significant acclimation effects of perennial ryegrass were observed in our studies. Acclimated cultivars (AC, cold framed conditioned plants) of perennial ryegrass exhibited greater freeze-stress tolerance than non-acclimated plants (NA, greenhouse conditioned plants). AC plants had significantly lower (more negative) LT50 estimates than NA plants based on whole-plant survival evaluations (Table 3). AC tissues had a mean lethal killing temperature (LT50) of -8.4 °C (+16.9 °F) compared to NA plants that had a mean LT50 of only -1.8 °C (+28.8 °F). The range in cultivar LT50 values for AC plants (-3.0 to -14.7 °C) was substantially greater than observed for NA plants (+3.9 to -4.2 °C).

After four weeks of regrowth, a visual count of survivors of AC plants showed that some plants from a few cultivars had survived temperatures as low as -21 °C (-5.8 °F). However, there were no survivors of NA plants exposed to temperatures lower than -7 °C (+19.4 °F). The 25 °F lower killing temperature for AC plants compared to NA plants indicate the importance of cold acclimation to low temperature survival. These results also suggest that perennial ryegrass maintained in an unheated polyhouse had sufficient time to adjust (acclimate) to freezing temperatures after 2 1/2 weeks in the cold frame (Fig. 1) and therefore tested the ability of ryegrass to acclimate quickly.

Difference in hardiness between performance groups

Perennial ryegrass cultivars that consistently performed well (ranking in the top 5%) in turfgrass variety trials at the Maine-Orono NTEP location were distinctly different in freezing survival from their poor-performing counterparts (cultivars ranking in the bottom 5%). Based on LT50 estimates, the high-performance cultivars (LRF-94-C8, Palmer III, Prelude III, Repell III, and Top Hat) had superior whole-plant survival following exposure to freezing treatments compared to the low-performance group (DSV NA 9401, DSV NA 9402, Linn, Pennfine, and SR-4010). AC plants for high-performance cultivars were able to survive lower temperatures indicated by a lower (more negative) mean LT50 estimate (-10.9 °C or +12.4 °F) compared to the low-cultivar group (mean LT50 of -6.0 °C or +21.2 °F, Table 3).

Visual differences between cultivar groups in shoot density following low temperature exposure were striking after four weeks of recovery in the greenhouse (Fig. 2). Such losses in shoot density that were observed with low-performance cultivars with decreasing temperature have obvious implications for these ryegrasses under the extreme low temperatures typical of the Maine-Orono location (Table 2).

The mechanism of freeze-stress injury was directly related to injury to cell membranes (Fig. 3). Specifically, high-performance cultivars experienced significantly less leakage of cell electrolytes (an indication of less cell membrane disruption) compared to poor-performing ryegrasses.

Differences between performance types in whole-plant survival were closely associated with injury at the cellular level. In general, hardened (acclimated) ryegrasses and high-performance cultivars were less sensitive to freezing-injury with decreasing tem-

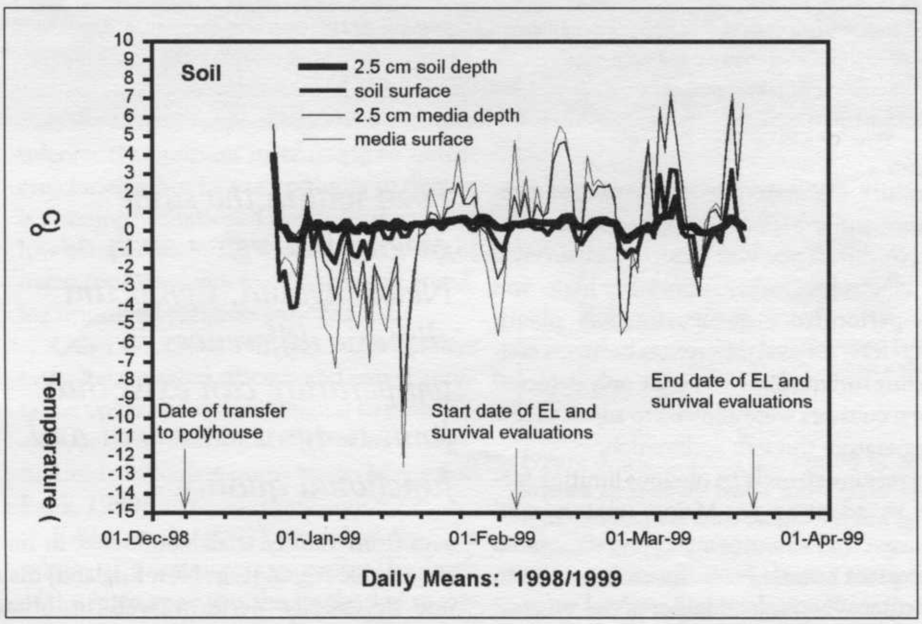

Figure 1. Mean daily soil temperature comparison between actual soil and plant container media at various depths during the experimental period.

TABLE 3. COMPARISON OF LT_{50} ESTIMATES FOR HIGH AND LOW PERFORMANCE GROUPS OF PERENNIAL RYEGRASS.

	LT50 (°C) by environment	
Cultivar	Acclimated (AC)	Non-acclimated (NA)
High performance group		
LRF-94-C8	14.7	-3.7
Palmer III	-10.0	-2.9
Prelude III	-9.3	-4.2
Repell III	-10.2	-2.7
Top Hat	-10.1	-1.8
Mean-high group	-10.9	-3.0
Low performance group		
DSV NA 9401	-3.9	-2.2
DSV NA 9402	-8.3	-1.2
Linn	-3.0	+3.9
Pennfine	-11.8	-2.7
SR-4010	-3.0	-1.1
Mean-low group	-6.0	-0.7
Mean by environment	-8.4	-1.8
Significance (p-value)		
Mean high vs. low†	0.05	NS
Mean AC vs. NA‡	0.001	

†Comparison between group means within environment (AC and NA).
‡Comparison between AC and NA means.
NS=not statistically significant.

perature compared to nonhardened ryegrasses and low-performance cultivars.

No difference was detected in survival (or electrolyte leakage) between high- and low-performance groups for NA plants. Therefore, survival differences between contrasting turf quality types were only detected when cultivars were allowed to adjust to low temperature through acclimation.

Freezing stress is an obvious limiting factor in adapting to Maine winters, and improved low-temperature survival is an important criteria for turfgrass managers to consider when selecting perennial ryegrass genotypes for northern environments.

Research has shown that winning cultivars from variety trials conducted in one geographic region (e. g., New England) may not necessarily perform well in other regions where cool-season turfgrass is adapted (USDA, 1997). Even within the

Even within the same geographic region such as New England, significant climatic differences in temperature can exist that limit turfgrass survival and functional quality.

same geographic region such as New England, significant climatic differences in temperature can exist (Table 2) that can limit turfgrass survival and functional quality. For example, the winning genotypes (top 5%) from the Maine NTEP location (Table 1) are different from the winning genotypes from the Rhode Island NTEP location. Use caution when extrapolating NTEP results from outside your own geographic zone or when extrapolating our results.

Important considerations

It is important to recognize that turfgrass quality (the basis for selection of high- and low-performance groups used in this study) is an integration of several components described earlier. The loss in shoot density caused by direct low-temperature kill is one of many stresses operating during the year that may limit turfgrass growth and quality. Superior low-temperature survival alone does not necessarily equate to superior turfgrass performance.

The cultivar Pennfine, a low performance type (Table 1), possessed superior low-temperature survival characteristics (LT50) similar to high-performance cultivars (Table 3). Pennfine's poor (low) rating in variety trials is in part due to its susceptibility to leaf spot (Bipolaris spp.) and brown patch (Rhizoctonia solani) disease (USDA, 1997). Consequently, it shares some of the attributes in common with high-performance cultivars (superior low-temperature tolerance) important in adapting to northern climates, but its susceptibility to disease is a major limitation. Therefore, improved low-temperature survival is just one of many considerations in selecting and breeding improved turfgrass varieties.

Other important turf-forming properties include improved disease and insect resistance, enhanced environmental stress tolerance, and reduced mowing, fertilizer, irrigation and pesticide requirements (Meyer and Funk, 1989).

Eagles et al. (1993) suggested that the release of apical dominance after the death of the main apex was the method of recovery in perennial ryegrass. The main apex of perennial ryegrass is killed at higher temperatures compared to lateral tiller buds. They also reasoned that profuse tillering could have a beneficial effect on recovery by providing more tiller buds as potential sites for regrowth. Shoot density measurements obtained from NTEP reports (USDA, 1997) indicate the high-performance group had significantly more shoots compared to the low group. This implies the potential for greater tillering and winter survival with high-performance cultivars as suggested by Eagles et al. (1993).

Freezing-stress resistance is a complex physiological process, complicated by inherent genetic differences between species and cultivars (Table 3); physiological alterations in freeze-stress resistance (hardening or dehardening) caused by management inputs (mowing height, nitrogen and potassium levels, thatch levels, plant growth regulator use and timing, and drainage considerations); and influenced by climatic differences that can exist from region-to-region and year-to-year (Table 2), affecting the intensity of low-temperature stress and the physiology of hardening or dehardening.

In the end, superior low-temperature survival is closely linked to improved performance and function. It is important to appreciate and understand how to effectively manage those species having poor or

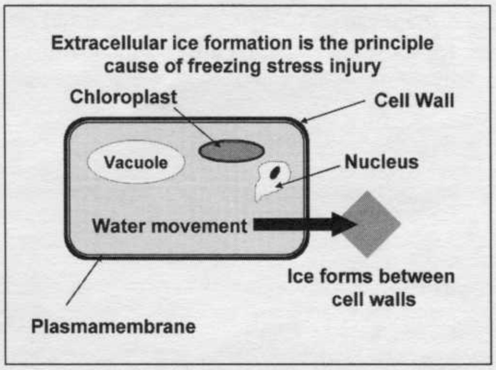

Figure 3. Mechanical disruption of cell membranes caused by water movement out of cells associated with the formation of extracellular ice (between cell walls). Injured (leaky) cells can be measured using conductivity bridges; higher electrical conductivity equates to greater injury (disruption of plasmamembrane).

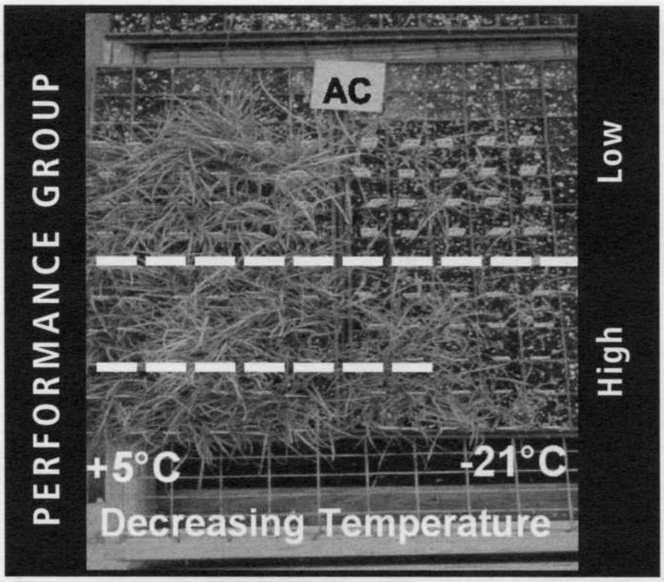

Figure 2. Regrowth survival of acclimated perennial ryegrass (5-low performance cultivars, upper half; 5-high performance cultivars, lower half) at 4 weeks following exposure to freezing temperatures. Note the higher shoot density (recovery) with high-performance cultivars under extreme low temperature.

marginal freeze-stress resistance such as perennial ryegrass, tall fescue and annual bluegrass to ensure maximum survival and functional quality in northern zones. The complex nature of low-temperature hardiness is not fully understood. Research is still needed to better understand the relationship between various management practices on acclimation (and de-acclimation) for those species and cultivars susceptible to low-temperature kill.

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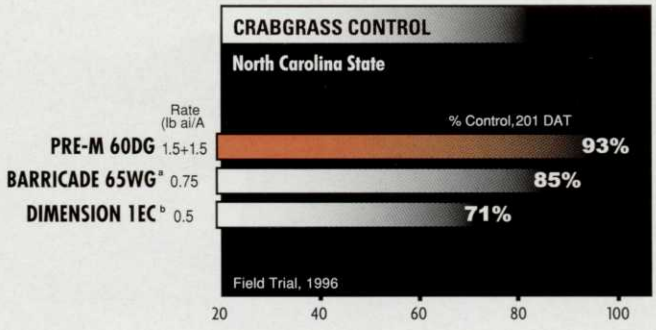

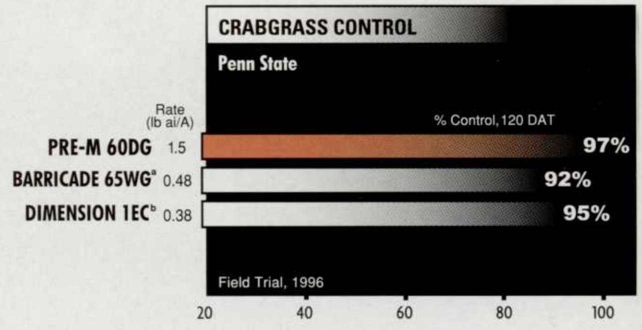

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*Source: Kline & Company Report, US Acre Treatments by Turf Management.

Four Unconventional Grasses to Know and Love

By Doug Brede, Ph.D.

Most turf managers can probably count on two hands all the grass species they've grown and mowed over the years. These same 10 grasses can take the average person from cradle to grave without any sweat. But we both know *you're* not an average person, or you wouldn't be reading *TurfGrass Trends*, right?

The "Big-10" turf species – bluegrass, fescue, rye, bermuda and the like – comprise probably 90% of turfgrass grown in this country. The remaining 10% falls into a category I call the unconventional turfgrasses – a group of perhaps 400 lesser known species, with varying levels of turf suitability. So what would drive a person to take the plunge into the wild world of unconventional turfgrasses? And what benefits do they offer that the "Big-10" turfgrasses lack?

Think about your turf facility for a moment. Do you have a spot that is hard to keep grassed? Maybe it dries out prematurely. Maybe it is shady or stony or excessively cold. It's spots like those that can drive a good manager nuts. It's also a good place to try an unconventional grass.

Knowing when and where is the secret to these grasses. In this article, I'm going to introduce you to a couple grasses you've probably heard of – but never knew when to plant – and a couple you've probably never heard of at all. And I'll explain how to put them to work to fill those crazy spots you just can't seem to keep green.

What's with wheatgrass?

Most turf folks have heard of crested wheatgrass and have seen textbook photos of how it blankets miles of Kansas roadways. But beyond that, they have little appreciation of where it might fit in their landscape.

Wheatgrass has a couple of noteworthy firsts to its record. 'Fairway' crested wheatgrass was the very first turfgrass cultivar ever developed. Fairway was released from the University of Saskatchewan in 1932, decades before the dawn of 'Penncross' and 'Merion.' Wheatgrass has also been credited with saving America from the Dust Bowl, which devastated crop and rangeland in the 1930s and plunged the Central Plains into depression.

The wheatgrass family is comprised of 100 Eurasian species and 22 to 30 North America natives. They are a fractured clan of grasses all distantly related to cultivated wheat grain (1). This connection has led wheat breeders to the wheatgrasses in hopes of creating inter-species crosses. Their goal is to invent the elusive perennial wheat which, if developed, could be planted once and would yield grain each summer without repeated tillage and resowing.

Fairway crested wheatgrass was the very first turfgrass cultivar ever developed — back in 1932.

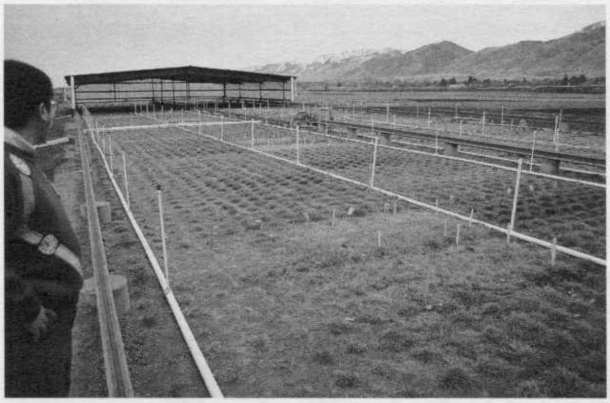
Originally, plant taxonomists lumped all the wheatgrasses together under Agropyron cristatum. But recent work at Utah State University (Figure 1) has regrouped these grasses into other genera. Only crested wheatgrass has remained among the Agropyron. Some wheatgrasses were switched to the Pascopyrum genus, others to Thinopyrum, and a few to the new Pseudoroegneria genus.

This reclassification was not merely a Latin name change. No, it went so far as to take varieties of the same species and split them into distinctly separate species. As a result, you'll find confused buyers and sellers clinging to the old Latin names in their

'Roadcrest' (rear of photo) and 'Ruff' (foreground) crested wheatgrass plots at Utah State, showing their turf adaptation under limiting moisture conditions. These grasses hold promise for roadsides and for drought-affected, low maintenance sites on golf courses and parks.

business transactions. Both the old and new Latin names are used almost interchangeably in seed catalogs.

Crested wheatgrass is the most turf-worthy member of the wheatgrass clan. It is native of the Steppe region of Russia, introduced to North America in 1892. Crested wheatgrass is well suited to the semiarid climate of the Great Plains and has become one of its prime rangegrasses. It also prospers on drier sites along the East Coast.



Automated rainout shelter experiment at Utah State University in Logan. A movable roof (left, rear of photo) rolls into place when sensors detect precipitation, allowing researchers to gauge drought tolerance based solely on irrigation levels. This facility was used in the development of the data in Figure 1.

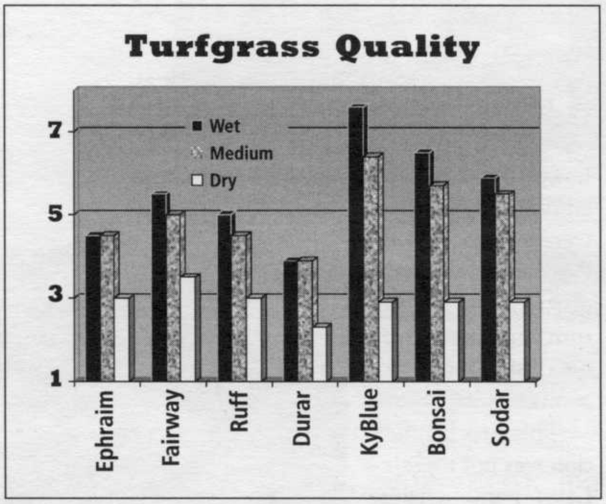


Fig. 1. Summer turf quality of 7 grasses at Utah State University, Logan, UT, maintained under 3 moisture regimes (2). The trial was conducted under a sophisticated rainout shelter (see photo) which automatically closes when it senses precipitation. 'Ephraim,' 'Fairway,' and 'Ruff' are crested wheatgrasses, 'Durar' is a hard fescue, 'Bonsai' is a tall fescue, and 'Sodar' is a streambank wheatgrass (Elymus lanceolatus). The lsd0.05 values for the wet, medium, and dry treatments were 0.4, 0.4, and 0.6, respectively.

Fairway wheatgrass has found use in a number of turf applications, including roadside, lawn, park, and even a few golf fairway plantings. It is persistent and competitive against weeds, as long as the cutting height is not too short and it's not given too much irrigation. Wheatgrass – like many prairie-grasses – looses its competitive edge against weeds when supplied with too much irrigation.

In recent decades, Kay Asay and Kevin Jensen, USDA researchers in Utah, have taken the lead in wheatgrass technology. Their work has led to the recent release of 'Roadcrest,' a rhizomatous cultivar with improved turf characteristics (see photo on page 9).

Asay and his colleagues have also performed a number of management studies on wheatgrass, comparing its drought tolerance with the traditional turf species (Fig. 1). He concluded one study by stating that "all the crested wheatgrass entries were easier to establish and initiated growth earlier in the spring than Kentucky bluegrass, hard and tall fescue, thickspike wheatgrass and perennial ryegrass."

Asay found that 25 to 30 lbs./acre seeding rate was the highest practical rate for wheatgrass. At higher seeding rates, wheatgrass became prone to damping off. "Fungal diseases occurred in the wheatgrass during seedling establishment when subjected to irrigation levels and heavy seeding rates recommended for Kentucky bluegrass, tall fescue and perennial ryegrass," he concluded.

A steady supply of relatively inexpensive crested wheatgrass seed has launched this species into a number of mowed and unmowed turf applications.

Detractors argue that crested wheatgrass is overused and other grasses would be better suited. They lament that wheatgrass is used in solid plantings rather than in mixed stands, limiting genetic diversity. They cite the fact that crested wheatgrass is an introduced grass, not one native to North America.

Yet in spite of its criticism, the value of crested wheatgrass is unmistakable. Crested wheatgrass' water-use efficiency, relatively good mowing tolerance, resistance to salinity and ability to crowd out noxious weeds has made it a valuable lawn and conservation grass for the drier, cooler parts of the world.

If it's June, this must be Junegrass

Prairie Junegrass (Koeleria macrantha) is on the verge of becoming a mainstream turf species. For years, marketers at Barenbrug, a multinational seed company centered in Holland, have been promoting their "new" variety of Junegrass called 'Barköel.' Barköel was an accidental discovery by company breeders in 1973 who thought they were picking up eye-catching plants of perennial ryegrass.

Junegrass looks and acts most like perennial ryegrass and can be used in similar applications on a golf course.

"The original breeding stock for Barköel was located by chance on an old British golf course," says Barenbrug's Michel Mulder (8). "Despite drought and infertile soil, certain attractive plants were found thriving whilst others suffered."

Junegrass looks and acts most like perennial ryegrass and can be used in similar applications on a golf course. While the Barköel variety can be used on fairways, 'common' Junegrass is better suited to roughs and out-of-play areas due to its coarser texture.

Acceptance of Junegrass in the marketplace has been slow, probably owing to its lower yields and higher seed prices than perennial ryegrass, its chief competitor. Junegrass' main advantages over ryegrass is its wear tolerance and super high shoot density. In British wear trials, Barköel regularly comes out near the top of the trial. It is uncertain whether the same can be expected in the continental U.S. due to the hotter, drier summers.

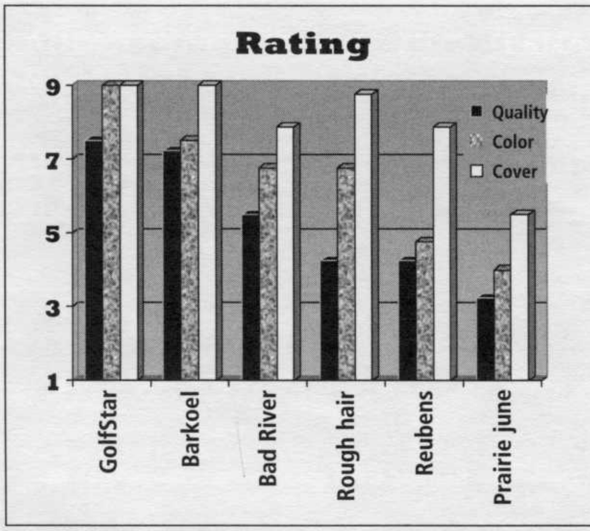


Fig. 2. Turfgrass quality, color and ground coverage of 6 grasses at Carman, MB, judged on their adaptation to low maintenance golf course sites (6). The trial was repeated at Winnipeg, MB, with similar results. 'GolfStar' is an Idaho bentgrass (Agrostis idahoensis), 'Barköel' is a prairie Junegrass, 'Bad River' is a blue grama, rough hairgrass is Poa scabra and 'Reubens' is a Canada bluegrass (Poa compressa). The rightmost bar of prairie Junegrass is a Canadian ecotype of Koeleria gracilis from Prairie Seeds. The lsd0.05 values for quality, color and cover were 1.0, 1.8, and 1.0, respectively. Ratings were on a 1 to 9 scale, with 9 equal to best. Cover ratings were transformed from a % scale to fit this axis.

Koeleria (Junegrass) is a common, cool-season bunchgrass throughout much of the world. You may have seen it and never knew what it was. Certain prairie Junegrass ecotypes possess turf adaptation.

Junegrass is not unique to Europe. It can be found in nature throughout much of the globe. Local ecotypes range from coarse to fine bladed. Most southern ecotypes are susceptible to winter damage.

In recent years, Anthony Mintenko and Ray Smith of the University of Manitoba have tested Junegrass for its adaptation to

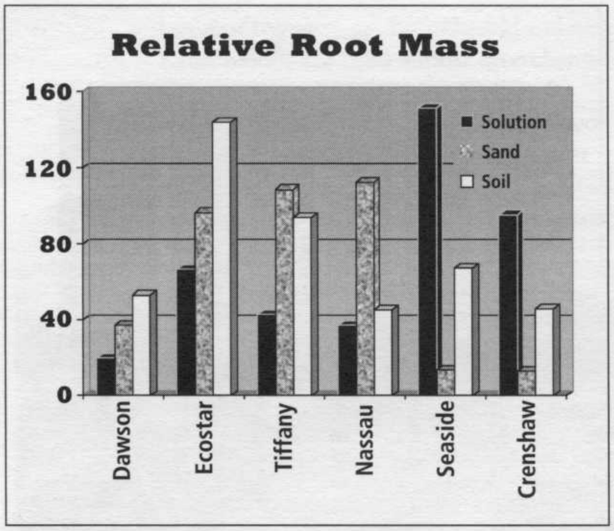


Fig. 3. Relative root mass of 6 grasses grown on aluminum-enriched media (5). Aluminum toxicity is an indicator of low-pH and heavy metal tolerance. 'Dawson' is a slender creeping fescue, 'EcoStar' is a hard fescue, 'Tiffany' is a Chewings fescue, 'Nassau' is a Kentucky bluegrass, and 'Seaside' and 'Crenshaw' are creeping bentgrasses. The grasses were tested in 3 growing media: Solution culture (which lacked a soil of any type), fine sand, and Tatum soil from Orange, VA, with a pH of 4.4.

lower maintenance golf course sites (6). Results have been promising (Fig. 2).

"In the summer months, the top entries were the cool-season grasses, 'GolfStar' Idaho bentgrass and Barköel Junegrass, followed by the warm-season grass, 'Bad River' blue grama," says Mintenko. "Blue grama maintained a consistent color during the peak heat periods of summer and, surprisingly, the two cool-season grasses mentioned above also held their color. The native Alberta prairie Junegrass showed poor quality and color when subjected to summer heat stress."

In the past two years, breeding powerhouse Rutgers University has got into the Junegrass business in a big way. They've made Junegrass collections in Europe and North America and are hybridizing them to produce improved varieties.

Remember, people laughed in 1967 when Rutgers originally brought out 'Manhattan' perennial ryegrass, saying there was little future in that species. Early indications are that history is about to repeat itself.

You're looking mighty slender today

Nearly every turf manager in the temperate zone has used fine fescue at one time or another. It performs well under trees because of its outstanding shade tolerance. The delicate, needle-like leaves of fine fescue combine well with other cool-season turfgrasses.

There are five basic species of fine fescue: Chewings, strong creeping red, slender creeping, hard, and sheep. Most people are familiar with the first two. And for low maintenance conditions, hard and sheep have become popular. But for many people, slender creeping fescue is a mystery.

Slender creeping fescue (Festuca rubra ssp. litoralis) is most similar to creeping red fescue (as its Latin name implies) but it has smaller seed, a smoother leaf sheath, and longer, thinner rhizomes. To generalize, slender creeping fescue forms a dense, light green, slightly less drought tolerant turf than its strong creeping red cousin. Of course, there are immense varietal differences among the two species.

There are five basic species of fine fescue: Chewings, strong creeping red, slender creeping, hard and sheep.

Depending on who you talk to, slender creeping fescue is either heaven or hell. Europeans love it. For them, slender creeping fescue produces a dense, fine-leafed stand with a compact growth habit.

In America, however, the National Turfgrass Evaluation Program (NTEP) trial has been ruthless to the slender creepers (7). Varieties of slender creeping fescue inevitably end up near the bottom of the trial results.

About 10 years ago, my company submitted 'Logro,' a European-bred slender creeping fescue into the NTEP trials. Logro had long been a top European performer. But for all five years of the NTEP trial, it held a stranglehold on last place. Some within our company commented that

'NoGro' might be a more appropriate name.

The slender creepers prosper under a cool, moist, European climate. In Canada, slender creepers perform best in coastal zones, where it tolerates shady, damp soils. Slender creeping fescue also has a reputation of good resistance to heavy metals. However, recent studies have shown that its heavy metal and low pH tolerance are only moderate compared to other popular turf varieties (Fig. 3). Slender creeping fescue has slightly better salt tolerance than other fine fescues, but it is not as tolerant as weeping alkaligrass.

Newer slender creeping fescues like 'Barcrown' and 'Seabreeze' offer improved turf quality and low cut tolerance and have performed well in places like Pennsylvania (4) and Europe.

ADDITIONAL READING ON ALTERNATIVE GRASSES — ONLINE

Readers with an Internet connection can find more information on these and other alternative turfgrasses at the following web sites:

- **USDA plant species search engine –** http://plants.usda.gov/plants/
- **Australian native grasses –** http://www.shoalhaven.net.au/~farrar/seedpg24.htm
- **Characteristics of any grass in the world –** http://biodiversity.uno.edu/delta/grass/index.htm
- **Low maintenance grass seed by mail –** http://www.seedsource.com/shop2/index.htm, or http://www.sunmarkseeds.com/, or http://www.graniteseed.com, or http://www.jacklingolf.com

Australia's best since Crocodile Dundee

When discussing new and innovative grasses, Australia generally doesn't come to mind. But it should. Aussie breeders have been busy in recent years quietly discovering and developing a host of native turfgrasses.

The climate across the populous part of Australia ranges from a cool, marine climate in the south to tropical in the north. The bulk of the country is an arid Mediterranean climate, reminiscent of Colorado or California. Some of the Australian native grasses hold potential for filling the turfgrass needs for similar regions in North America and around the world.

Under low maintenance conditions, weeping grass from Australia forms a moderately dense turf, reminiscent of perennial ryegrass. The variety 'Griffin' was bred for turf, 'Shannon' for roadsides and 'Wakefield' for pasture.

Weeping grass (Microlaena stipoides) is a cool-season grass found only in Australia, New Zealand and adjacent islands. Like Junegrass, it occurs in a wide range of growing conditions and ecotypes. Some of these ecotypes have shown possibilities for turf, including mowing tolerance down to 1-in. cut. Under mowing, weeping grass can develop high density, moderate to fine leaves, and a low fertility requirement. One particular endearing feature is its tolerance of low light and shade – a trait that's lacking in most warm-temperature grasses.

Weeping grass resembles a perennial ryegrass with rhizomes. In turf, it grows in a somewhat bunchy, weeping fashion, as its name implies. It stays green all year, including the winter and during moderate heat and drought in summer.

Seed germination is not as quick as perennial ryegrass but more similar to Kentucky bluegrass. Shallow planting and a mulched seedbed enhance emergence. The seed also possesses a whisker that should be removed during seed processing to improve germination and flow through a spreader.

Trifluralin can even be used during planting to eliminate weed emergence, while permitting the weeping grass to grow normally.

Management studies at the University of Melbourne indicate that weeping grass is tolerant of the usual preemergence herbicides, such as trifluralin and pendimethalin (3). Trifluralin can even be used during planting to eliminate weed emergence, while permitting the weeping grass to grow normally. Ethofumesate, dithiopyr and bensulide are not recommended.

Seed of weeping grass is produced in commercial quantities in Australia and is available for export to the US. 'Griffin,' 'Shannon' and 'Wakefield' are improved varieties, with the former being bred for turf. Most larger seed houses can obtain seed upon request. Remember, seed harvest in Australia occurs in February. Waiting until August to place your order may leave you empty handed.

— The author has had a lifelong fascination with low maintenance grasses. Brede earned a Ph.D. degree at Penn State University, working as an assistant superintendent for a 27-hole golf course near Pittsburgh, PA, in between degrees. After graduation, he took a job at Oklahoma State University, replacing Wayne Huffine, a noted roadside turf researcher. He continued two of Huffine's long-term projects on low maintenance turf and pursued a variety of fine turf interests. After receiving tenure, he was off to take the research director's job at Jacklin Seed/Simplot Turf & Horticulture in Post Falls, ID, where he works today. Brede recently authored a book dealing with useful ways for lowering your turf maintenance – making turf care easier rather than more complicated. The book, entitled "Turfgrass Maintenance Reduction Handbook - Sports, Lawns and Golf," is at the presses and is expected to ship in August. The book lists 400 additional unconventional grasses, other than the 4 mentioned here – all with turf possibilities. You can find the book on the web at Amazon.com and the publisher (www.sleepingbearpress.com).

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This article is the first in a series for Turfgrass Trends, describing in detail four grasses from among the hundreds you can know and grow. If you find this information useful, please let the publisher know. If there are varieties you are considering for your operation that you would like discussed, drop Doug Brede a note at rpower@jacklin.com or 208/773-7581 x224 and he might discuss them in another article down the road.

Managing Stress of All Sorts

If there's an issue this time of year, it is stress. It is a stressful time of year for everyone in our business. First, we deal with turfgrass stresses. It is hot, and everyone knows what that means to the grass. But lest we forget that turf comes under stress at other times of the year, Scott Ebdon of the University of Massachusetts looks at winter stress. And upcoming issues of *TurfGrass Trends* will offer other views of turfgrass stress.

Stress on people & equipment

The second part of the job under stress is equipment. The season is about halfway through in the Northern areas. That means equipment has been stressed for a couple of months. Maintenance schedules might have been allowed to slip a bit to accommodate those extra working hours.

Best check with the shop and make sure everything is up to date. Better now to tighten a few belts or change the oil than have to deal with the stress of a major overhaul during a real crunch time.

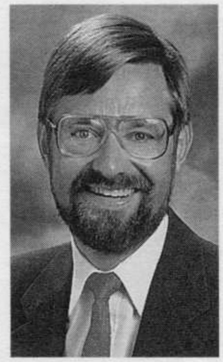
If you and your staff are feeling stressed this time of year, that's normal. In fact, this piece might have increased your stress level as you thought about seeding and maintenance that needed to be done last week. Keep in mind that most stress in humans is self-induced. Often, it is a lack of planning, or a need to adapt to changes in plans, that gives rise to stressed-out feelings.

Most stress is the result of managers feeling that their situation has gone out of control.

In fact, industrial psychologists say that most stress is the result of managers feeling that their situation has gone "out of control" and that other elements – perhaps a boss, the weather, staff resignations – are running things.

A simple to-do list can help. So can delegating authority and responsibility. Use others to help you manage the situation. Prioritize – realize that everything won't get done today (or even this season). Keep in mind that your sanity and serenity are keys to the staff working well.

If all else fails, grab that rusty iron from behind the pro shop and when nobody's looking, whack some balls into the distance. It's far better to relieve stress by running or pounding a pillow than it is to take it out on your employees or others.



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