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PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 350 projects at a cost of $29 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

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Genetic Improvement of Prairie Junegrass

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SUMMARY

The University of Minnesota has initiated a germplasm improvement program for prairie junegrass. Although this native species has several characteristics that indicate it should be successful low-input turfgrass, there are several challenges that must be met. Our research program is focused on collecting and identifying germplasm that possesses characteristics that will lead to an improved, functional, turf-type cultivar. To date, we have initiated several research projects and preliminary results indicate:

- Significant variability for seed production characteristics exists in the USDA germplasm collection.
- Native germplasm does not currently exhibit sufficient mowing quality or establishment rate.
- Native germplasm possesses several advantageous characteristics including ability to survive significant droughts, slow vertical growth rate, excellent winter hardiness, and early spring green-up.
- This species has the potential to be a valuable species in golf course roughs and other low-input environments.

Recently, increased attention has been focused on the environmental effects of turfgrass areas such as home lawns and golf courses. In Minnesota, the most well-known of these efforts is the ban on phosphorus fertilizers for turf areas in the Twin Cities metro area (7). This legislation has since been extended to include the all 82 counties of the state (11). These types of restrictions on golf course inputs are likely to increase in future years.

According to Lyman et al. (9), there are approximately 172,000 acres of golf course rough in the North Central region that are planted to Kentucky bluegrass (*Poa pratensis* L.) and perennial ryegrass (*Lolium perenne* L.). Neither of these species is native to the U.S., and both require routine inputs of nutrients and water to maintain desirable turf characteristics that provide functionality and aesthetics.

Researchers need to identify new options for golf course superintendents so that further restrictions of commonly-used turfgrass inputs do not negatively affect the golf industry in Minnesota and other states. Because native grass species may be better able to cope with our environment and lead to overall reductions in inputs such as pesticides, fertilizers, and water, we have initiated a germplasm improvement program focused on prairie junegrass (*Koeleria macrantha* (Ledeb.) J.A. Schultes).

Prairie Junegrass

Prairie junegrass has been successfully used as a turfgrass in lower-input environments

Selection criteria for cultivar development of prairie junegrass include resistance to infection by rust pathogens (shown above) and resistance to pink snow mold.

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In July 2005, researchers collected germplasm in western Nebraska and northeastern Colorado (shown above). The collections resulted in 78 accessions from a total of 10 sites. Germplasm was also collected in western North Dakota (2006), southeastern Minnesota (2006), and South Dakota (2007).

(2, 4, 8, 10). The species is native to the Great Plains and is widely distributed throughout much of the western United States (6), as well as Europe and Asia (3). Its range can extend north to 60^{o} N in Europe, 62^{o} N in Asia, and 55^{o} N in North America (3).

Prairie junegrass has several attributes that would make it a useful low-input grass in Minnesota. The species is reported to be tolerant of droughty and alkaline soils (11) and is also adapted to sandy areas (5, 6). The species can survive extreme temperatures: 39^{o} C during the summer in Spain and -50^{o} C average monthly minimum temperatures in Siberia (3). Prairie junegrass is relatively slow growing. According to Dixon (3), plants in an unmowed nursery did not grow to more than 12 cm in diameter after three years. This slow-growth characteristic could be advantageous for turf use due to the potential reduction in mowing costs.

'Barkoel', released by Barenbrug Holland, was the first cultivar of this species specifically developed for use as a turfgrass. The cultivar originated from ecotypes collected in Europe. Clones were selected based on good winter color and seed yield (1). In a low-input trial that included 12 species native to North America, 'Barkoel' was the top-performing turfgrass over two years (10). Although 'Barkoel' was selected from ecotypes collected in Europe, this research showed the potential of the species as a low-input turfgrass.

The species has shown potential as a low-input turfgrass in New Jersey (4) and appears to perform at an acceptable level in Minnesota under low-input conditions which includes no supplemental irrigation, limited nitrogen application, and no fungicide or insecticide applications. The species did not perform very well in a regional low-input turfgrass evaluation (13); however, the cultivar that was evaluated was not developed for turfgrass use. Information about turf performance of native populations of the species is lacking.

Based on our preliminary trials, the major limitations of this species are (i) poor mowing quality, (ii) slow rate of establishment, and (iii) summer dormancy under severe drought stress. Other limitations are also evident (leaf rust, pink snow mold). However, these are not as potential-

ly problematic as the three primary limitations. In order for this species to be improved to a point that it will be useable for managed turf, we will need to address each of these challenges with extensive research and breeding efforts.

Breeding and Selection Initiatives

The major limitation when developing a breeding program for a "new" species is the availability of germplasm from which a useful cultivar can be developed. In July 2005, we collected germplasm in western Nebraska and northeastern Colorado that resulted in 78 accessions from a total of 10 sites. Plants in the collection areas were typically growing in very hot, dry conditions on relatively infertile soils, suggesting that these genotypes have the potential to do well as low-input turfgrasses. In this case, a collection is the

Improved cultivars of prairie junegrass would need much improved mowing quality compared to this native type.

total seed from one seedhead taken from an individual plant. Individual plants were selected based on several characteristics including color, crown density, seedhead number, uniformity of maturity, and freedom from disease.

Using individual plants to conduct research on this species would not have allowed a thorough examination of turfgrass traits due to seed quantity limitations. Developing breeding populations addressed this problem. In 2006, breeding populations of the species were assembled on the St. Paul campus. Plants originating

In 2006, breeding populations of the species were assembled on the St. Paul campus. Plants originating from germplasm collections were planted into a breeding nursery in fall 2005.

from germplasm collections were planted into a breeding nursery in fall 2005. In June 2006, plants from each collection site were moved into 10 individual crossing blocks. Each block represented a single collection site. It is assumed that accessions from a single collection site have a high degree of genetic similarity.

The plants were allowed to intercross. Seed was harvested individually from each plant in a block and bulked. This bulked seed was considered a representative sample of the collected germplasm from a single collection site (bulked seed from an individual crossing block will hereafter be referred to as a 'breeding population'). In addition to these collections, germplasm was also collected in western North Dakota (2006), southeastern Minnesota (2006), and South Dakota (2007). These collection efforts have provided an

Researchers have used approximately 50 of the 96 accessions available for testing from the Western Regional Plant Introduction Station in Pullman, WA.

Rank	Origin of Accession†	Average yield/plant (g)‡
1	Iowa, USA	20.1
2	Kazakhstan	10.4
3	Ukraine	10.1
4	Russian Federation - Stavro	9.5
5	Bulgaria	8.8
6	Former Soviet Union - Stavro	7.3
7	Russian Federation	6.6
8	Mongolia	6.2
9	Former Soviet Union	5.2
10	Canada	4.7
11	Turkey, Bilecik	4.1
12	Turkey, Ankara	3.3
13	Yugoslavia	3.2
14	Ireland	2.6
15	Iran	2.4
16	Turkey, Afyon	2.0
17	Turkey	1.7
18	Armenia	1.6
19	South Africa	1.3
20	New Mexico, USA	0.3
21	Pakistan	0.04
	$LSD_{(0.05)}$	3.1

†Data grouped for accessions from the same region.

‡Yield was only measured on surviving plants that produced seedheads.

Table 1. Average yield of accessions (2008) in a seed production evaluation at Becker, MN.

excellent germplasm base with which to work.

A second important source of germplasm is the United States National Plant Germplasm System (NPGS). Currently, the NPGS lists 96 accessions as being available for testing from the Western Regional Plant Introduction Station in Pullman, WA. We have used approximately 50 of these accessions in several trials. Although not all of the accessions are native to the U.S., these accessions may provide valuable traits that are not found in native germplasm.

Current Research Efforts

In order for a cultivar of this species to be used on a wide scale, two criteria must be met: 1) the cultivar must possess adequate turfgrass quality in a medium- to low-maintenance management situation, and 2) the cultivar must possess adequate seed production traits so that a sufficient supply of seed can be produced at a reasonable cost. The breeding populations discussed above, and additional germplasm from government col-

lections were used to in several trials designed to address these criteria.

Seed Production Evaluation

A spaced-plant seed production evaluation trial was planted in spring 2007 at two locations in Minnesota (St. Paul and Becker). The Becker location is located on a very sandy soil and provided a distinctly different environment from St. Paul site, which has a much heavier soil. The trials consisted of approximately 50 germplasm collections from the NPGS representing germplasm from throughout the world. In 2008, data was collected on important seed production traits including date of anthesis, number of seedheads, height of flowering culms, total seed weight, average individual seed weight, and seed germination.

We found significant variation among accessions. Collections that showed high levels of seed production potential included germplasm collected in Iowa. Collections with low levels of seed production were generally from areas of southwestern Asia. Based on these results, we will place additional focus on the inclusion of local collections in our breeding program in order to improve seed production potential of the species. Results from the Becker location are presented in Table 1.

Turf Trials

A turfgrass trial was planted in spring 2007 on the St. Paul campus. The trial included germplasm that had primarily been collected in North Dakota and had undergone one cycle of selection in our breeding program (a very limited number of lines originating from Colorado and Nebraska were also included). The trial is being managed under low-input conditions (no irrigation after establishment, low fertilizer inputs, no pesticide application). Ratings have been taken for one year. The trial is not replicated due to seed quantity limitations, so statistical analysis is not possible.

During 2008, most plots showed very poor mowing quality and became dormant very quickly during stress periods; however, they recovered

Significant variation among accessions was found. Collections that showed high levels of seed production potential included germplasm collected in Iowa; low seed-producing accessions were generally from areas of southwestern Asia.

A turfgrass trial was planted in spring 2007 on the St. Paul campus. The trial included germplasm that had primarily been collected in North Dakota (shown above) and had undergone one cycle of selection in the breeding program

from dormancy quite rapidly after the stress was relieved, and there was variability in the response, which indicates potential to breed for better summer color and mowing quality in this population. Because germplasm in this particular trial is not geographically diverse, broad assumptions about the overall germplasm collection can not be made. Ratings will be taken for several characteristics for the next two years.

A second turf trial consisting of 625 plots was planted as a dormant seeding in November 2008. The entries consist of selections from two breeding nurseries that were harvested in summer 2008. Each nursery consisted of germplasm originally collected from Minnesota, Colorado, or Nebraska. The nurseries both consisted of individual rows of 5 plants for each breeding line which was replicated 8 times. In the first nursery, uniform, productive rows were bulk harvested (maximum of 5 plants per bulked sample). The seed was cleaned and used to plant replicated turf plots (3 replications) in the dormant-seeded trial.

In the second nursery, individual plants that exhibited high seed production were harvested and used to establish turf plots. This turf trial will allow us to compare these two methods of selection and to determine which breeding lines have the most potential for use as low-input turf in sustainable landscapes. This trial will also be managed as low-input trials (no supplemental irrigation after establishment except to prevent total turf loss; 3-inch height of cut; no pesticides). These two turf trials will (1) help determine if the species has the potential to be a useful turfgrass and (2) help answer some turfgrass management questions that will assuredly arise once a cultivar is released for public use.

Mowed Spaced-plant Evaluation

A mowed spaced-plant evaluation (Trial A) was planted in spring 2007 in both St. Paul and

Becker. The purpose of this trial is to determine the heritability of important turfgrass quality characteristics. Over 300 genotypes are currently being evaluated for important turfgrass quality traits such as color, density, mowing quality, drought stress, winter hardiness, and disease resistance. The genotypes for this study originate from collections made in Colorado, Nebraska, North Dakota, and Minnesota. A similar trial (Trial B) was established using plant introduction from NPGS similar to that used in the seed production trial mentioned previously. We hope to identify traits in international collections that can be useful for our program.

In 2008, data was collected on all listed traits. In Trial A, the amount of variability for most traits is limited due to the fact that most germplasm was collected from very similar environments. Germplasm in Trial B showed high levels of variability for most traits. Integration of characteristics from non-native germplasm, such as that found in Trial B, may help solves some of the most difficult issues that have been found in the native germplasm (i.e. poor mowing quality and slow establishment rate).

Drought Tolerance

In 2008, we began screening our breeding populations for drought tolerance. Approximately 95 genotypes representing the diversity of our native germplasm collection were clonally propagated in the greenhouse. After establishment in the greenhouse, plants were transferred to a growth chamber with 16-hour days and 25/15^{o} C day/night temperatures. Plants were fully saturated, and water was then withheld for the duration of the experiments. Plants were visually rated weekly for the amount of green tissue remaining.

The most drought tolerant genotypes will be compared with least tolerant genotypes in further studies in cooperation with Dr. Yiwei Jiang at Purdue University. These evaluations will help us understand the mechanisms for drought tolerance in this species so that we can develop cultivars that maintain green color throughout the summer stress periods.

Salinity Tolerance

The presences of saline soils in parts of the country, along with salt damage from road maintenance in cold climates such as Minnesota, presents a challenge for turfgrass managers. There are very few salt-tolerant grass cultivars available for use. Developing a salt-tolerant cultivar of prairie junegrass for use in northern climates would be a great benefit to turfgrass managers.

The first step in the long-term objective of a salt-tolerant cultivar is to determine salinity tolerances of current prairie junegrass germplasm. We have initiated a cooperative research effort with Dr. Qi Zhang from North Dakota State University to determining the salinity tolerance of our breeding populations. The results from this work will also help us identify mechanisms for salinity tolerance in the species.

Conclusions

The ultimate goal of our research is to release a cultivar of prairie junegrass developed primarily from native germplasm that can be used on golf course roughs and in other low-input environments. We expect that this goal will take some time to achieve; however, the efforts outlined above will help accelerate our progress.

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