Heritability Estimates and Accession Evaluation in *Distichlis spicata* (Development of Turf-type Seeded Saltgrass)

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Abstract: Conserving water in the landscape is critical to the management of turfgrass in the arid portions of the western United States. Native accessions of the inland form of saltgrass [Distichlis spicata var stricta (Torr.) Beetle] were collected and evaluated for turf potential in Colorado and Arizona. Since saltgrass is non-domesticated, this research selected plants for four traits needing improvement to develop turf-type saltgrass cultivars. Resistance to leaf rust (*Puccinia aristidae*, Tracy), short height, high shoot density, and high seed yield were traits that made up a selection index which ranked all 158 accessions collected from the Front Range of Colorado, the Great Basin, South Dakota, and Nebraska. The top 14 females and 12 males of these were top-crossed, and progenies were evaluated. Response to selection was recorded for all four traits. Realized heritability, narrow sense heritability from half-sib analysis, narrow sense heritability from parent-offspring regression, and broad sense heritability were very high for height and shoot density. Broad sense heritability and narrow sense heritability from half-sib analysis were high for seed yield, but narrow sense heritability from parent-offspring regression and realized heritability were moderate. A major gene for rust resistance was noted. Negative heterosis measured on the midparent for short height and seed yield were noted. Positive heterosis occurred for shoot density. Accessions were grouped by their region of origin (four), and analyzed for the above four traits, as well as days to flower, spread, gap, seed length, and a measure of the female head height. There were significant differences among regions for most traits. The indication of a major gene for rust resistance suggests ease of incorporating resistance, although durablility may be reduced with a single gene. Collecting from the Front Range rather than the Great Basin and Central Plains, would be more effective in developing a turf variety because this area contains accessions with better values for turf traits. Significant responses to selection and/or very high heritability estimates indicate breeding to change these traits will not be difficult.

Introduction: Inland saltgrass is a dioecious, rhizomatous, perennial, salt-tolerant, warm-season grass, indigenous to Western North America and Australia. It is commonly found in saline environments, including saline/alkali salt flats, where it is often a dominant species. Characteristics of some inland saltgrass selections which might make it a desirable turf include fine texture, dark green color, and high shoot density. This species is highly tolerant of traffic, compaction, drought, heat, cold, and salinity. Breeding and management work at the University of Arizona and Colorado State University have produced promising lines that display high turf quality under close mowing. Native saltgrass stands generally produce little seed, and that seed usually exhibits low germination rates. Our breeding efforts appear to have yielded lines that produce more seed, and continuing research has dramatically increased our ability to produce turf stands from seed.

Materials and Methods:
Nursery formation: Colorado State University, in cooperation with the University of Arizona, has created the only known turf-type saltgrass germplasm collection to date. In order to construct the original source nursery, a total of 158 accessions were collected from 4 regions (the Front Range of Colorado, the Great Basin, South Dakota and Nebraska) from1999-2001.

Breeding for saltgrass follows the recurrent selection procedure:

- The 4 traits deemed most in need of improvement for achieving higher turf quality in saltgrass are (in order of importance): resistance to rust (*Puccinia aristidae*), short height, shoot density and seed yield. Appropriate measurements were taken and accessions were ranked, based on a selection index, to determine lines with highest turf quality.
- A parent population of at least 25 individuals was maintained in each breeding population to avoid the negative effects of inbreeding depression.
- Polycross mating blocks were planted for creation of open-pollinated maternal half-sib families for statistical analysis and population improvement.
- Digital imaging was used to measure the spread of plants (Olympus C-5000 digital camera).
- SAS version 9.2 was used to perform the analysis.

Results:
Table 1: Response to selection, heritability estimates, heterosis, and major gene detection. Realized heritability uses Front Range population for reference. Other heritabilities use parents as reference population. *single year data . NA=not applicable

	Response to selection	Realized heritability	Narrow sense heritability half-sib families	Narrow sense heritability parent-offspring	Broad sense heritability from parents	Heterosis against midparent	Major gene
Rust resistance (%leaf area in pustules)	-1.2%	0.19	NA	NA	NA	NA	Yes
Height in cm	-2.8 cm	0.77	0.94	0.99	0.92	Negative	No
Shoots/ cm^2	1.8/cm^2	1.74	0.94	0.93	0.96	Positive	No
Seed yield Gms/(30 cm^2)	4.0 g *	0.42 *	0.84 *	0.45 *	0.80	Negative *	No

Table 2: Trait means by region. Asterisk denotes significant differences from other regions for a trait towards the favored value for selection as a turf trait.

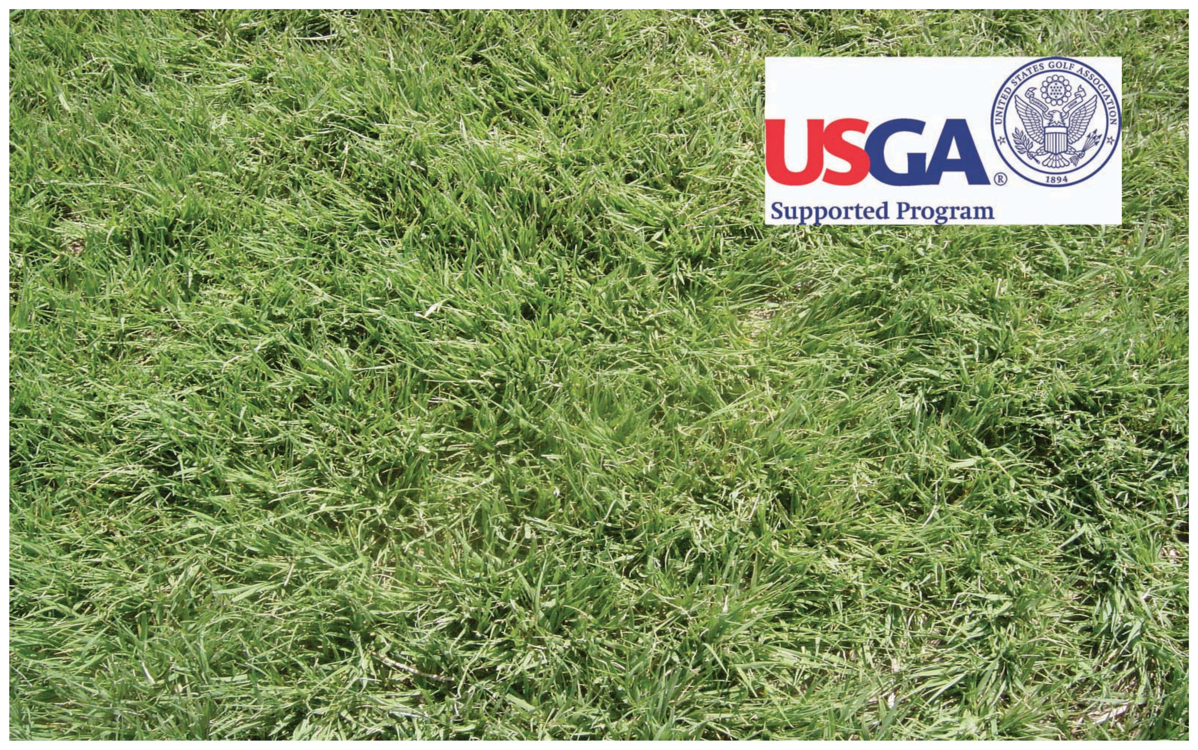
Trait / Region	Front Range	South Dakota	Nebraska	Great Basin
% leaf rust area	8.76 % *	2.64 % *	4.00 % *	14.46 %
Canopy height	18.45 cm *	22.57 cm	22.53 cm	19.47 cm *
Shoot density	4.67/cm^2 *	3.29/cm^2	3.80/cm^2	4.04/cm^2
Seed yield	6.61 gm	4.40 gm	2.93 gm	5.52 gm
Days to first flower	147.0 *	143.1	146.4 *	146.3 *
Spread	50.6 % *	22 %	21.6 %	33.8 %
Gap	9.7 % *	37 %	29.7 %	21.9 %
Seed length	3.7 mm	4.2 mm *	4.3 mm *	3.0 mm
Height head/ Height canopy	0.43	0.46	0.43	0.90 *

Conclusions:

- Accessions collected from the Front Range have the highest values for turf quality.
- High values for narrow sense heritability suggest phenotypic selection for turf traits should be effective.
- Heterosis in shoot density and rate of spread can be taken advantage of in specific crosses.
- Rust resistance is most likely controlled by a major gene and shows low heritability.
- Over half of the females at the Horticulture Field Center in Fort Collins, CO produce commercially acceptable levels of seed.
- Seed dormancy can be partially overcome with a day to night temperature difference of 16 C. Scarification has also shown to be effective in breaking seed dormancy.
- Unpublished data showed a movement of the relatively deep horizontal rhizome mass in saltgrass closer to the surface due to breeding for the 4 turf traits.
- Recombination in later generations should moderate negative heterosis seen in seed yield and short height and make selection more effective in these traits.

2010 polycross containing elite parents

The development of seeded turf-type saltgrass is important because deep rhizome growth makes sod production difficult and expensive.



Current and Future Work: Two full breeding cycles have been completed since the start of the project and in 2010 the top 17 females and 11 males were selected from the second generation nursery. This latest selection of 28 lines represents the most promising turf-type saltgrass cultivars developed by CSU to this point in time. They are currently planted as parent clones in isolated polycross blocks at the CSU Horticulture Field Research Center in Fort, Collins, CO.
Seed was harvested from the 2010 polycross blocks in September 2012 (third generation seed) and it will be planted in the field in Spring 2013 for conducting progeny evaluations. If visual uniformity and mowing quality is deemed acceptable after conducting the progeny evaluations, the clonal parents from the 2010 polycross block could potentialli be used to develop a synthetic cultivar. These parents are currently being multiplied vegetatively in the greenhouse as a backup source of elite germplasm and to have material for seed companies interested in potential commercialization of a saltgrass cultivar release. A new source nursery was also planted in 2012 as an additional pool for selection. It is constituted of plants grown from bulk seed collected from the first generation. Initial data has been collected on shoot height and rate of spread of over 560 individual plants.

Top selection from 2012 nursery (14 weeks old)

Goal of Current Work: The overall goal of this project is to develop a seeded turf-type variety of inland saltgrass (*Distichlis spicata*). Use of this grass would allow golf courses to conserve potable water because of its tolerance to lesser quality (reclaimed water, saline ground and surface waters) water resources while producing attractive turf and providing excellent playing conditions. It would also have an advantage in parks and home lawns as an option for a drought, salt, compaction, and wear tolerant turfgrass. In addition, inland saltgrass has value for use in revegetation projects.

Literature Cited:

Cluff, G.J., R.A. Evans, and J.A. Young. 1983. Desert saltgrass seed germination and seedbed ecology. Journal of Range Management 36:419-422.

Harrington, J.E. 2000. Overcoming seed dormancy in Distichlis spicata. M.S. thesis. Colorado State University, Ft. Collins, CO.

Hughes, H., D. Christensen, T. Koski, and Scott Reid. 2002. Desert saltgrass: A potential new turfgrass. USGA Turfgrass and Environmental Research Online 1(12): 1-4.

Kopec, D.M. and K. Marcum, 2001. Desert Saltgrass: A potential new turfgrass species. USGA Green Section Record (Jan/Feb 2001): 6-8.

Qian, Y. L., J. M. Fu, S. J. Wilhelm, D. Christensen, and A. J. Koski. 2007. Relative salinity tolerance of turf-type saltgrass selections. HortScience. 42(2):p. 205-209.

Qian, Y. L., J. A. Cosenza, S. J. Wilhelm, and D. Christensen. 2006. Techniques for enhancing saltgrass seed germination and establishment. Crop Sci. 46:2613-2616.

Shahba, M. A., Y. L. Qian, and K. D. Lair. 2008. Improving seed germination of saltgrass under saline conditions. Crop Sci. 48:756-762.

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