information for seashore paspalum resistance to individual and multiple soil stresses. This approach also is highly effective in identifying seashore paspalum ecotypes with *high nutrient uptake efficiency* and *drought resistance* via possessing a deep, extensive, viable root system. Root tolerance assessment to the major edaphic stresses has been a *missing ingredient* in most breeding programs targeted to improve drought resistance, water-use efficiency, or nutrient-use efficiency.

Study 1. Eighty-four seashore paspalum ecotypes and three control grasses (Common bermudagrass, TIFWAY bermudagrass, and Meyer zoysiagrass) were plugged (3.5 in. diameter x 3.0 in. deep) on 30 June 1998 into two adjacent sites at 4.5 feet centers. Both sites were a Cecil kaolinitic clay soil with 23 percent clay (A-horizon) and 45 percent (B-horizon). Site A was at pH 4.2 to create the acid soil complex stress which consists of aluminum/magnesium toxicities and potential deficiencies of manganese, potassium, calcium, and phosphorous. Site B was at pH 6.5. Both sites imposed the root stresses of high soil strength in a non-cracking soil, drought stress, and high soil temperatures.

At 24 days after plugging, irrigation was stopped and all grasses experienced periods of 8, 15, and 12 days without water from 24 July to 15 September. Mowing was at 1.25 inches and fertilization was at 1.0 lb N per 1000 ft^2 as 10-10-10 on 8 July.

Multiple soil stress response was evaluated based on a *Stress Index* that was a combination of two factors, a) the rank of the grass according to the degree of spread over 77 days after establishment at pH 4.2, and b) the ratio of growth (area covered) at pH 4.2 divided by growth at pH 6.5. Grasses that exhibited high growth under the severe soil stress of pH 4.2 situation should be able to grow and persist under a variety of irrigated and non-irrigated field conditions. The ratio of growth (area covered) at pH 4.2 divided by growth at pH 6.5 allows for identification of grasses with the highest tolerance to the acid soil complex stress. This stress is common in the Piedmont Region of the United States and very prevalent in tropical climates. Grasses with the highest ratio (1.0, equal growth at both pH's; < 1.0, less growth at pH 4.2 than pH 6.5) were ranked highest. Performances of selected grasses are in Table 8.

Study 2. Nine fairway type seashore paspalums and TIFWAY bermudagrass were stolonized on 16 July 1998 at a normal rate (0.75 bushels per 1000 ft^2). These will be evaluated in 1999 through 2000 under fairway conditions for shoot/root performance, evapotranspiration (ET) or water use, and overall drought resistance.

Table 8. Performance of selected grasses to multiple soil stresses (high soil strength, drought, acid soil complex, high soil temperature) that limit root development, viability, and persistence.

Grass	Stress Index Value	Stress Index Rank	Tolerance to Multiple Root-Limiting Soil Stresses
Hi 32 SP	15 (best)	1	Superior
HYB 7 SP	16	2	
HI 34 SP	17	3	
AP 4 SP	27	4	Very High
COMMON Bermuda	29	5	
PI 28960 SP	29	5	
TCR 6 SP	30	6	
96 HI 10 SP	31	7	
TIFWAY Bermuda	34	8	
AP 15 SP	34	8	
PI 509023	36	9	
Taliaferro SP	36	9	
TCR 3 SP	37	10	
AP 10 SP	38	11	
K 1 SP	38	11	
K 2 SP	39	12	
HI 101 SP	39	12	
Fwy 1 (PI 509019-1) SP	48	20	High
ADALAYD SP	67	32	Moderate
MEYER zoysiagrass	75	38	Low
Mauna Key SP	113 (worst)	54	Very Low

[a] Greens type, projected release 2000; very high salinity tolerance.
[b] Fairway type, projected release 2000; high salinity tolerance; high drought tolerance.

Selection of Turf Type and Seed Production in Inland Saltgrass (*Distichlis spicata*)

Colorado State University

Harrison G. Hughes

Start Date: 1998
Number of Years: 5
Total Funding: $125,000

Objectives:

1. *Determine turf performance of 7 elite CSU-USGA lines, 7 elite University of Arizona lines, 7 Great Basin lines (check lines from the University of Arizona).*
2. *Determining the range of stress tolerance (drought, salinity) present in inland saltgrass.*
3. *Determining seed production of 7 elite CSU-USGA lines.*
4. *Evaluate Kopec collection and Northern Great Plains collection.*
5. *Evaluation of seed germination and seedling vigor of all crosses.*
6. *Evaluate RAPD as a means of identifying unique genotypes of saltgrass.*
7. *Determine the relative chromosome number of elite clones.*
8. *Study the viability and germination requirements of inland saltgrass seed.*
9. *Evaluate seed priming as a possible method by which germination can be improved.*

Initially, elite lines from the University of Arizona collection and the CSU-USGA lines were established in both Arizona and Colorado. This initial year was a grow-in year with data on turf quality and seed production to be observed in future years. The material in Arizona will be used for drought studies in the field as well. CSU-USGA elite lines previously established in Colorado were observed for flowering and seed set. Seed production was evident but shattering was a problem. An extensive nursery consisting of the Arizona lines as well as additional lines from a collecting trip to Utah, Nevada, South Dakota and Nebraska with approximately 200 accessions was established at the CSU Horticulture Research Center outside of Fort Collins.

In order to understand seed fertility of inland saltgrass, a study of chromosome numbers for genotypes found throughout the region was initiated. Variation in chromosome number can lead to low pollen or egg viability resulting in poor seed set. Root tip smears of 40 genotypes were observed with the most common chromosome number being $2n = 38$. However, 39, 42, 40, and 74 chromosome counts were observed. Coastal saltgrass was determined to have 40 chromosomes, as previously published and in our observations as well. This would indicate that our most commonly observed chromosome number of 38 is likely an aneuploid, probably a nullisomic.

Studies to determine pollen viability via examination of pistils demonstrated that pollen readily germinated in those clones examined. This was seen via microscopic examination of pistil structure. Furthermore, pollen tube growth reached the egg sac as well. Therefore, pollen viability is not apparently a problem in those clones observed. However, crossing among clones of different chromosome number may still influence successful seed production. In crosses among plants with 38 chromosomes and between 38 and 42 chromosomes, successful seed set was apparent. These seed have been germinated and will be examined in future studies. Due to high pollen viability and observable seed set, we believe that poor fertility as reported elsewhere is probably due to pollen availability rather than pollen quality or genetic deficiencies in most cases.

Three seed lots of inland saltgrass were examined for viability and germination. Seed viability for these lots was 15, 62 and 92 percent as determined by the tetrazolium (TZ) test. This low viability, in some cases, was probably due to a combination of extreme age, early harvest and poor storage conditions.

Inland saltgrass seed at maturity appears to be dormant and this dormancy is apparently due to the seed coat. Recently harvested seed lots that were scarified readily germinated in excess of 90 percent viable seed. For unscarified seed, alternating extremes of temperature prompted greater germination than moderate temperatures. Old seed exhibited low viability but seed that were determined to be alive via the TZ test germinated without scarification. ⌶

A Multigene-Transfer Strategy to Improve Disease and Environmental Stress Resistance in Creeping Bentgrass

Michigan State University

Mariam B. Sticklen

Start Date: 1998
Number of Years: 3
Total Funding: $75,000

Objectives:

1. *Enhance the expression (increase level of pest resistance) of the American elm chitinase gene in creeping bentgrass.*
2. *Transfer two drought-resistance genes controlled by either a constitutive or an ABA-inducible promoter into creeping bentgrass.*
3. *Determine disease resistance of transgenic plants expressing different levels of the chitinase gene and transgenic plants containing single-versus multiple-inserted genes under green house and field conditions.*
4. *Determine environmental stress resistance of transgenic plants containing single-versus multiple-inseted genes grown under greenhouse and field condiditons.*
5. *Evaluate transgenic creeping bentgrass clones for turf quality characteristics under field conditions.*
6. *Release transgenic creeping bentgrass germplasm with combined improvements in turf quality and pest and stress resistance to Pure Seed Testing, Inc. and/or other sectors for use in their field testing and commercial breeding program.*

Major biotic and abiotic problems associated in the management of creeping bentgrass turf include several pathogenic disorders and certain environmental extremes such as drought, heat, and cold stress. In addition, environmental extremes such as drought can influence the health of the plant and its ability to resist infection by biotic agents.

Resistance to biotic and abiotic stress in plants has been reported to be associated with relatively complex genetic factors. Most biotechnological approaches of the last two decades, especially those related to the control of insects and diseases, have concentrated on transferring a single gene into plants. The single gene approach may sound attractive over a short period; however, this approach may result in more serious problems over a longer period as populations of biotic agents (i.e., insects or pathogens) develop resistance the single gene. Our long-term goals include development of transgenic turfgrasses with improved resistance to pathogens and drought tolerance.

Previously, the research team developed creeping bentgrass clones that contain the glufosinate ammonia resistant herbicide, a chitinase gene, a proteinase inhibitor gene, and a drought and salt tolerance mannitol dehydrogenase (mt1D) gene. So far, it