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Researchers at Colorado State University continue to breed desert saltgrass in an effort to develop cultivars that are very salt and drought tolerant. Determining narrow sense heritability is of importance because it estimates how much of a trait visually present in parents will be passed onto its progeny. This paper describes their efforts to calculate the heritability of height in this potentially important native turfgrass species.

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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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Determining Heritability of Saltgrass Height

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SUMMARY

Narrow sense heritability is of importance because it estimates how much of a trait visually present in parents will be passed onto its progeny. Much variability exists for height in saltgrass collections, but heritability estimates are unavailable to estimate success in the start of a breeding program for short height. This is part of a larger study of inheritances of turf traits in saltgrass. Progress to date includes:

- 100 random vegetative collections were made from Cheyenne to Denver.
- Heritabilities were very high for estimates.
- Half-sib family estimates agreed with parent-offspring estimates.
- Family ranks of best linear unbiased predictions (BLUPs) changed from a dry year to wet year, indicating at least one family was not stable for height.
- Heritability estimates indicated that the prospect for a short saltgrass varieties is very good.

Desert saltgrass [*Distichlis spicata* var *stricta* (Torr.) Beetle] is a warm-season perennial grass native to western North America. It is in the subfamily Chloridoideae, which represents pioneer species that evolved in stressful, arid environments (7).

During the heat and drought in 2000 and 2001, a large collection of desert saltgrass remained green at the same time lines of blue grama, buffalograss, crested wheatgrass, and bermudagrass had turned brown from lack of rainfall (5). Desert saltgrass can tolerate salinity levels of 60,000 ppm NaCl (6), an amount exceeding sea water at 35,000 ppm. In addition, strong rhizomes, high shoot density, and short height found in saltgrass collections give it potential as a turf species.

Breeders like to use material that has a desirable (high or low) trait mean, and large genetic variance from which to make further selections (1). Broad sense heritability, H, is the ratio of total genetic variance to phenotypic variance. Narrow sense heritability, h2, is the ratio of additive genetic variance to phenotypic variance. Heritability values fall between 0 and 1.

Large additive genetic variance, versus dominance and/or epistatic variance in a trait makes selection easier because the trait can be visually selected for in parents, knowing it will be passed on to their progeny (2). Low additive genetic variance requires considerably more evaluation of the parents for selection to be effective.

Since saltgrass is a non-domesticated species, values for trait means and genetic variances are unknown. Height was chosen as a study trait because field observation indicated variability, and turf-types would need to possess a low mean height (8).

Researchers at Colorado State University are breeding desert saltgrass in an effort to produce a useful salt tolerant turfgrass. Heritability estimates are necessary to indicate how well a specific trait can be passed on to progeny. Heritability estimates for desert saltgrass height indicate that this trait can be passed on readily to progeny which greatly improves the potential of developing short, turf-type desert saltgrass cultivars.

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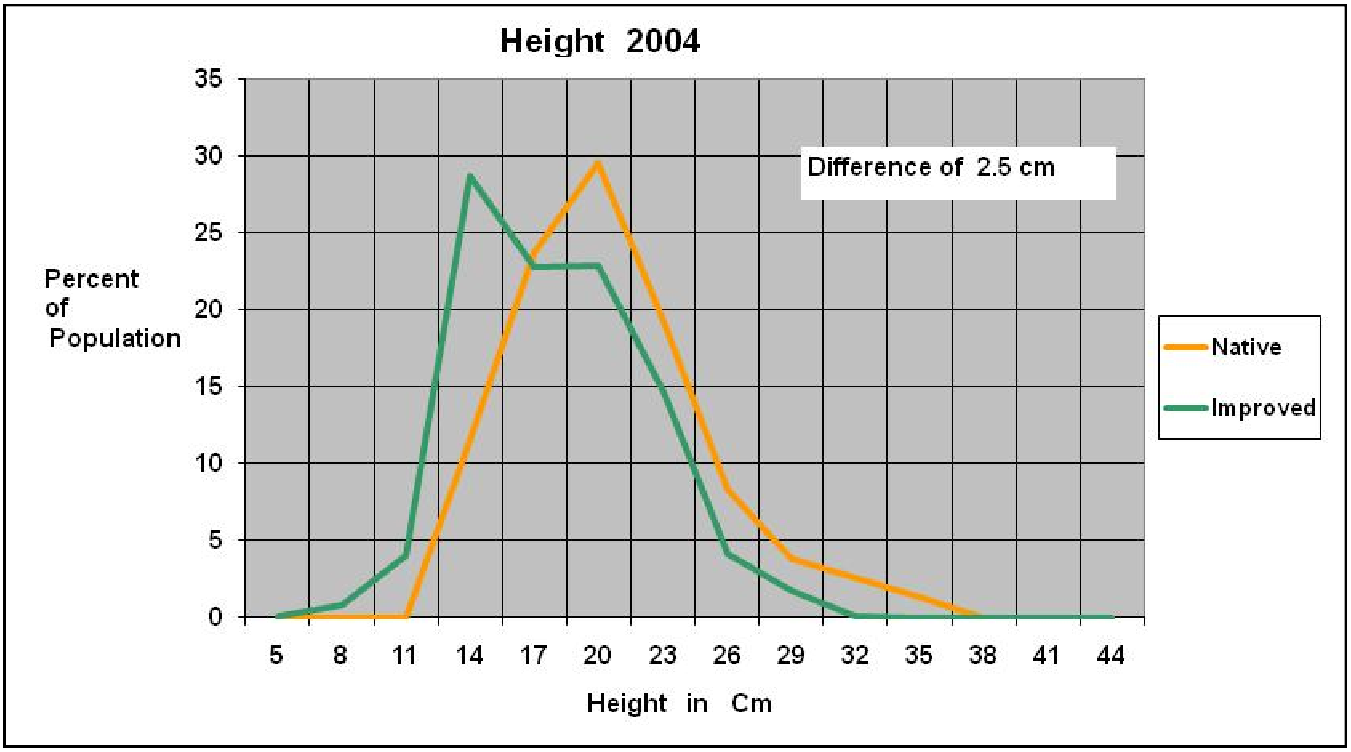

Figure 1. Height of native and improved populations in 2004.

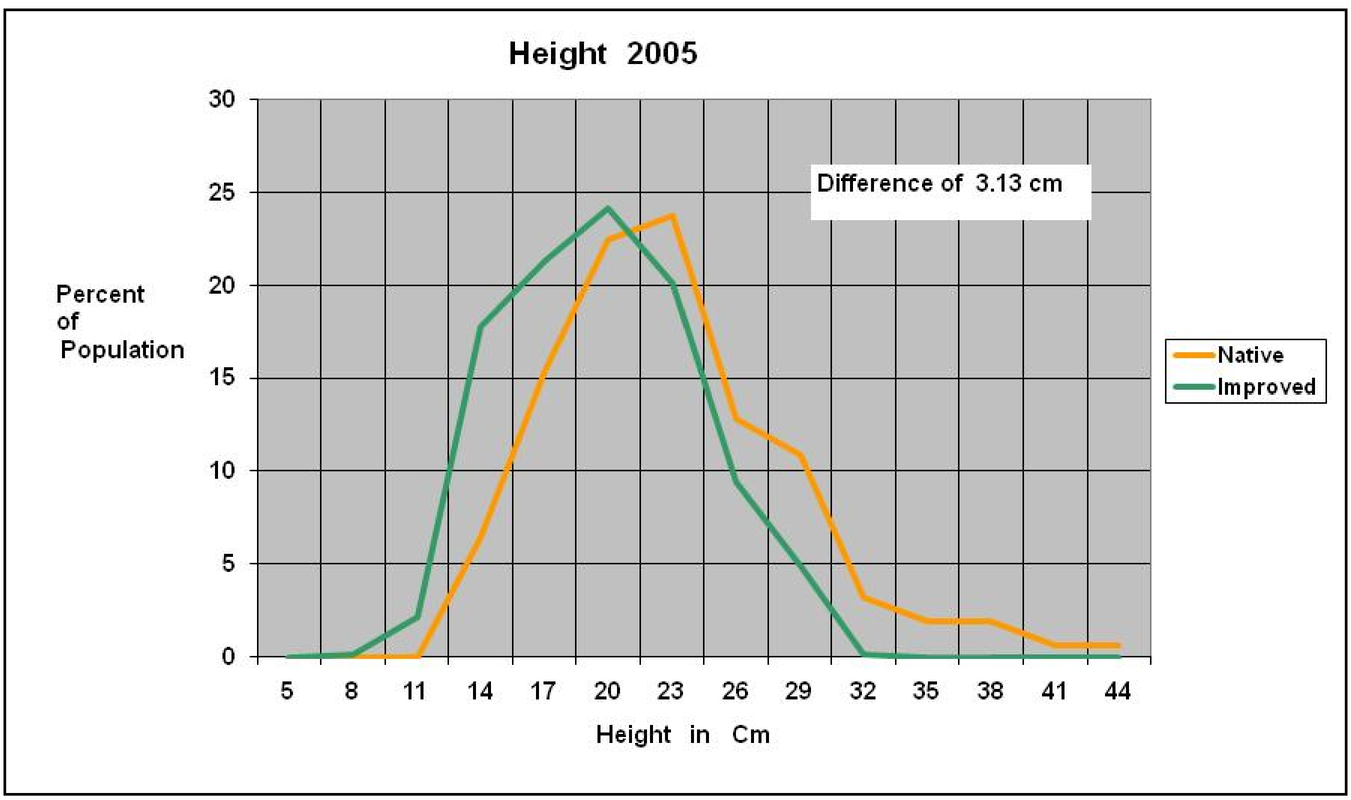

Figure 2. Height of native and improved populations in 2005.

Material and Methods

Random collections of 100 plants were made along the plains of the Front Range from Cheyenne to Denver from 1995 to 1998. A subset population of 12 males and 14 females was selected as parents for their short height and other traits. These came from a localized area and were considered a random mating population in order to meet criteria for the calculation and interpretation of heritability estimates. In August of 2000, a polycross of the parents was planted with 30 x 30 cm female plugs, replicated twice. Male plugs, 15 x 15 cm, replicated twice, surrounded each female plug.

Half-sib progeny were formed under random mating in a polycross from all crosses between 12 males and 14 females, and seed harvested to form 14 maternal half-sib families in 2002. Seed was germinated in December 2002 and 10 X 10 cm plugs were planted into the field in the first week of August, 2003. The soil is deep and the water table is at 7 meters. Nitrogen was applied annually at a rate of 90 kg/ha. Plants were sprinkler-irrigated at flowering with 13 cm water annually. The progeny test was a randomized complete block design with 6 replications and 14 maternal half-sib families, with 10 plants per plot. A parent and check plot (25 entries each) was replicated 6 times throughout the nursery. All measurements were on an individual plant basis. Canopy height was taken October 11 to October 12, 2004, and again August 23 to August 24, 2005.

The model for half-sib analysis and interpretation is based on a split-block in time (10, 11). Parent-offsping rergressions were based on means (9, 11, SAS Institute, Cary, NC).

Results

Selection for height was effective when comparing the native population (Cheyenne to Denver) with the progeny (improved population) of parents (subset population) selected for shorter height. Because year effect was significant in the statistical analyses, data is plotted by years (Figures 1 and 2). A summary of year means follows:

Year	Native	Improved
2004	20.6 cm	18.09 cm
2005	23.1 cm	19.97 cm

Desert saltgrass progeny planting in 2007 at Colorado State University research plots.

Family Rank 2004 (Dry)	BLUP (cm)	Family Rank 2005 (Wet)	BLUP (cm)
A138-1	14.9	A138-1	16.5
A53-1	15.4	A50-1	17.1
A50-1	15.7	A53-1	17.1
A61-1	15.9	A61-1	18.4
84-1	16.6	84-1	18.5
A126-1	16.8	A126-1	19.1
A97-1	18.0	A21-1	19.8
A34-1	18.5	A34-1	20.3
A21-1	18.5	A123-1	20.6
A24-1	19.2	A24-1	21.1
A123-1	19.5	A35-1	22.4
A37-1	20.8	A97-1	22.5
A18-1	21.1	A18-1	22.7
A35-1	21.6	A37-1	22.8

Table 1. Family rankings and best linear unbiased predictions (BLUPs) of saltgrass accessions in 2004 (a dry year) and 2005 (a wet year) in Fort Collins, CO.

Even though 2004 heights were taken with a month longer of growing season, they showed shorter height, possibly due to 5 cm less rainfall during the season. Replication was effective in taking out field plot variability. Families (which make up the improved population) were significantly different from each other. Plants within plots were significantly different. Interactions with year were significant, so family rankings changed from one year to the next. Because family rankings changed from one yar to the next, statistical analyses were opreformed for each year separately.

For each year, the statistical analyses indicated that replication and families were significant showing differences in height. From the combined years analysis, families ranked differ-

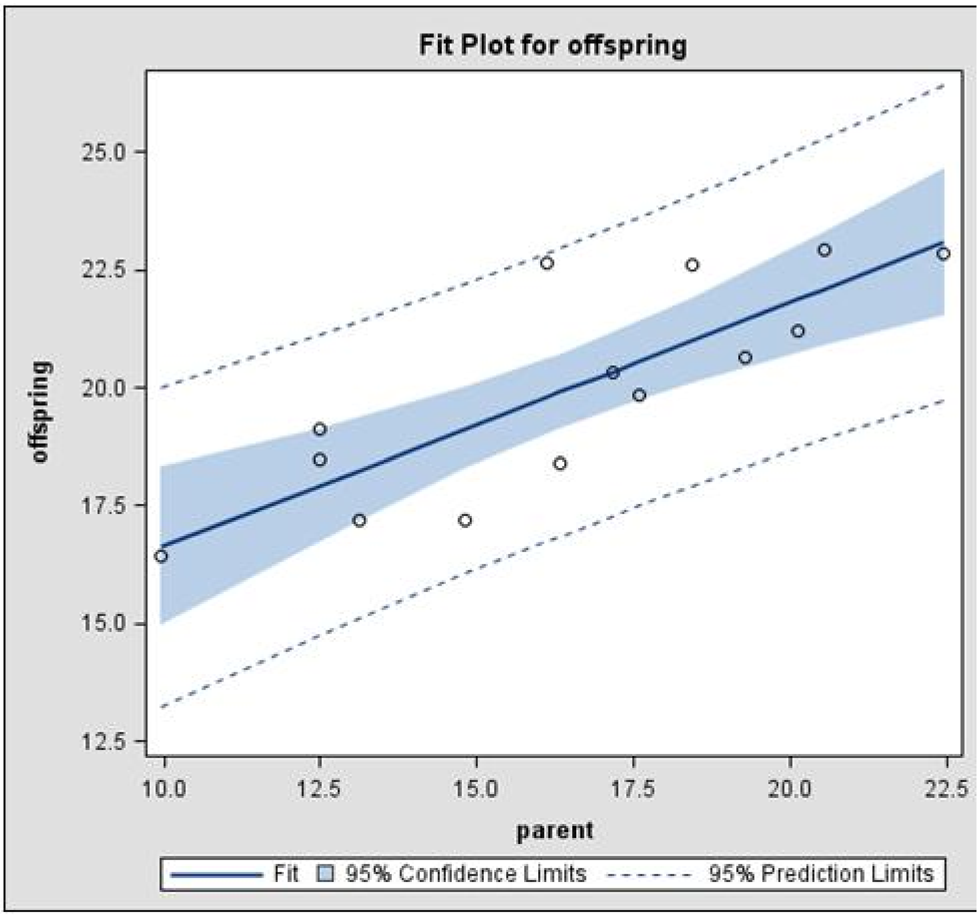

Figure 3. Regression of offspring in 2005 onto parents in 2004.

ently for heights from year to year. This indicates some maternal parents would have progeny showing a shorter height in one year than another year. Again, the cause for the difference in year effects could be due to the differences in precipitation observed.

Heritability is calculated from the variance components in the statistical analysis. Heritability estimates for each year would indicate response to selection for that particular environment. For example, 2004 was a drier environment, and 2005 was a wetter environment. A breeding objective could be to develop lines for each environment (each year, dry and wet), since an interaction exists. Or alternatively, only parents that have the best rank in both years and show stability across environments could be chosen. Narrow sense heritabilities in this case were calculated to be 0.97 in 2004 and 0.96 in 2005. These are very high. Such few environments in this study can bias the estimates higher.

Best linear unbiased predictions (BLUPs) were made from the families for each year (Table 1). These predict the performance of the maternal parent over the entire population of turf-type paternal parents to which it might be mated. Family A97-1 (all progeny derived from female A97) shows the largest change in rank. Family A97-1 changes from a rank of 7 in the drier year of 2004 to a rank of 12 in the wetter year of 2005. A97-1 may be more sensitive to moisture than other families and may be expressing this in taller height. Therefore, from a breeding standpoint, A97 could be culled since its progeny does not have a stable height across environments.

Parent offspring regression is a different method to determine narrow sense heritability. A family by year interaction is known from the previous analysis, therefore, separate regressions for each year were carried out. Since two years of data had been obtained, progeny were regressed onto parents of the alternate year. Regressing with different years removes some of the environmental covariance between parents and offspring grown in the same years. When the appropriate adjustments are made, narrow sense heritability etimates were calculated to be 0.98 for the parents in 2004 and progeny in 2005, and 1.00 for the 2005 parents and 2004 progeny. Regression using progeny in 2004, and parents in 2005 is graphed in Figure 3.

Both of these values, 0.98 and 1.00, are very high, but they are also in the range of heritability estimates obtained in the half-sib family analysis. Agreement between the two methods indicates half-sib analysis has not been inflated by gene linkage bias. Estimates do not represent the native population, however. Theoretically, these estimates should be lower than those in the native population (3, 4).

The heritability estimates for height in this experiment are high, and similar to that found in an initial breeding program for turf traits in bermudagrass (12). The bermudagrass germplasm was derived from accessions from 10 Agricultural Experiment Stations, whereas the saltgrass germplasm is collected from a small watershed in Colorado. The high estimates seen in saltgrass are, in part, an indication of heterogeneity and heterozygosity of the material. On the one hand, so much variability indicates that fixing turf traits in a variety may take time, but alternatively, the variability is available for selection. The is indication is that prospects for a short saltgrass variety are very good.

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