Annual Report
To: USGA-GCSAA
October 1987

Project Title: Breeding Improved Seeded Bermudagrass for Turf

Submitted By: Arden A. Baltensperger, Professor of Agronomy, NMSU

This report briefly covers the total bermudagrass breeding program at NMSU without regard to funding source. Much time and effort was devoted to variety release and ancillary activities for NuMex S-1 (temporary designation).

Variety Release:

Early in 1987 all data on our advanced strains were summarized and reviewed. It was decided to ask for release of NuMex S-1 and an application for release was prepared for the New Mexico Agricultural Experiment Station Variety Release Committee. This application compared NuMex S-1 with Common and Guymon for several turfgrass characteristics at several locations. (see attached Application for Release)

After approved for release, the New Mexico Crop Improvement Assoc. chose Farmers Marketing Corp. for exclusively increasing and marketing the variety. The NMSU bermudagrass breeding personnel assisted in establishing a 2.5 acre `Breeder Field' at Roll Arizona. Approximately 25,000 seedling of NuMex S-1 were established in individual containers and hand planted in the Arizona field in early July. Off-type plants were rogued in the greenhouse before transplanting and in the breeder field in August. A modest amount of seed is expected from a winter harvest of the `Breeder Field' for establishment of Foundation fields in 1988 by the seed company.

Breeding Program for 1986-87:

The third quantitative genetics study was completed. (See attached Ph.D. dissertation abstracts) These studies were designed to help guide the present breeding program at NMSU and also be of benefit for future breeding of bermudagrass. Heretability values for attributes such as seed yield, stem intermode length, leaf length, leaf width, color, density, and shade tolerance have been determined for a moderately large population of tetraploid bermudagrasses.

A study of the self-fertility of 10 bermudagrass genotypes of special interest to us in our breeding program was completed in 1987. The very low self-fertility of these clones compares favorably with results from other workers on tetraploid bermudagrass. It also indicates we should expect little effect from selfed seed in advanced generations of the plant material we are using in crosses. In 1987, continued crossing and continued phenetypic selection was made on material in the breeding program.

Application for Release of

NM S-1 Bermudagrass

Arden Baltensperger[1]

New Mexico Agricultural Experiment Station

January 26, 1987

Summary:

New Mexico S-1 is a new seed propagated, turf type bermudagrass cultivar. It was developed as an alternative to 'Common' which is presently the primary commercially available seeded turftype bermudagrass.

New Mexico S-1 was developed for medium texture, plant height and density, and is recommended for parks, playground and golf course fairways in the bermudagrass belt of the United States.

1/Professor of Agronomy and Horticulture Department, New Mexico State University, Las Cruces, New Mexico.

As signed

NEW MEXICO AGRICULTURAL EXPERIMENT STATION
NEW MEXICO STATE UNIVERSITY
LAS CRUCES, NEW MEXICO

NOTICE OF RELEASE OF 'NuMex S-1' BERMUDAGRASS

The Department of Agronomy and Horticulture and the Agricultural Experiment Station at New Mexico State University announces the release of 'NuMex S-1' bermudagrass, Cynodon dactylon (L.) Pers., a seed propagated cultivar with medium texture, density and plant height for general turf use. NuMex S-1 was developed by Arden Baltensperger and graduate students.

NuMex S-1 was developed from a polycross of 16 parental clones selected for high turf quality characteristics and good seed production. Based on polycross progeny performance, eight of the 16 original clones were intercrossed and subjected to two cycles of phenotypic recurrent selection for shorter internode length and increased density.

NuMex S-1 is a medium textured cultivar similar to 'Common'. Stem internode length, leaf length and plant height were found to be 19, 31 and 45% less, respectively, for NuMex S-1 than Common at Las Cruces, New Mexico. Visual spring and summer green color ratings were as high or higher for NuMex S-1 than Common at 12 test sites located in the southern part of the U.S. and turfgrass quality was observed to be equal to or superior to Common. As a result of the turfgrass quality and other performance evaluations, NuMex S-1 is expected to perform as good or better than Common throughout much of the bermudagrass belt of the United States.

Breeder seed will be maintained by the Department of Agronomy and Horticulture, New Mexico State University, Las Cruces, New Mexico, 88003. Seed increase will be on a three generation basis and grown under the supervision of a seed certifying agency.

Approximately two pounds of breeder seed is now available.

Approved:

Director, Experiment Station ______________ Date ______________

Head, Dept. of Agronomy and Horticulture ______________ Date ______________

Table 1. Texture ratings for mature turf of NM S-1 as compared to Common and Guymon in 1984 Strain Test at Las Cruces, New Mexico.

Entry	Texture[1/]
NMS-1	5.2
Common	5.2
Guymon	2.0
LSD (P=0.05)	0.9

[1/]Texture based on visual rating of 1 most coarse to 9 most fine from a total of two observations in 1985 and 1986.

Table 2. Plant characteristics of NM S-1 as compared with Common and Guymon in National Bermuda Turfgrass Evaluation Test at Las Cruces, New Mexico in 1986.

Entry	Leaf width[1/]	Visual texture[2/]
	--mm--	-rating-
NM S-1	3.3	5.0
Common	3.4	3.7
Guymon	4.0	3.0
LSD (P=0.05)	0.5	1.2

1/ Stem leaf width based on measurements from 15 stem leaves per plot.
2/ Visual texture rating based on 1 most coarse to 9 most fine.

Table 3. Texture rankings[1/] for NM S-1 as compared with Common and Guymon at several National Bermudagrass Test Sites in 1986.

Site	Entry		
	NM S-1	Common	Guymon
Kansas Wichita	4.7	3.7	3.3
Oklahoma Stillwater	4.3	3.7	2.0

[1/]Ratings based on visual estimates where 1 is most coarse and 9 most fine textured.

Table 4. Density ratings for mature turf of NM S-1 compared to Common and Guymon in 1984 Strain Test, Las Cruces, New Mexico.

Entry	Density[1/]
NM S-1	4.3
Common	4.0
Guymon	5.8
LSD (P=0.05)	1.3

[1/]Density based on visual ratings of 1 least dense to 9 most dense from two observations in 1986.

Table 5. Density rating[1/] for NM S-1 as compared with Common and Guymon in National Bermuda Turfgrass Evaluation Test at Las Cruces, New Mexico in 1986.

Entry	Density
NM S-1	6.3
Common	5.0
Guymon	6.7
LSD (P=0.05)	1.1

[1/] Single rating based on 1 least to 9 most dense.

Table 6. Density ranking[1/] for NM S-1 as compared with Common and Guymon in national Bermudagrass test at Wichita, Kansas in 1986.

Site	Entry		
	NM S-1	Common	Guymon
Kansas Wichita	4.3	3.0	3.3

1/ Ratings based on visual estimates when 1 is least dense and 9 most dense.

Table 7. Plant characteristics of NM S-1 as compared with Common and Guymon in National Bermuda Turfgrass Evaluation Test at Las Cruces, New Mexico in 1986.

Entry	Internode length[1/]	Leaf length[2/]	Plant height[3/]
	---mm---	---mm---	---cm---
NM S-1	42.8	68.5	17.3
Common	52.8	99.1	31.4
Guymon	23.7	56.5	13.1
LSD (P=0.05)	7.1	16.1	2.5

[1/] Stem internode length based on measurements from 15 stems per plot.
[2/] Stem leaf length based on measurements of 15 stem leaves per plot.
[3/] Turf height based on measurements from 9 locations in plots prior to cutting after 21 days growth.

Table 8. Color ratings for mature turf of NM S-1 as compared to Common and Guymon in 1984 Strain Test at Las Cruces, New Mexico.

Entry	Color[1/]		
	Spring[2/]	Summer[3/]	Fall[4/]
NM S-1	5.3	6.2	6.7
Common	3.3	6.0	5.0
Guymon	7.0	7.9	4.0
LSD (P=0.05)	2.3	1.0	1.6

[1/]Ratings based on visual estimate of color where 1 is least green to 9 most green.
[2/]Single rating in 1986.
[3/]Total of three ratings in 1985 and 1986.
[4/]Single rating in 1985.

Table 9. Color ratings for NM S-1 as compared with Common and Guymon in National Bermuda Turfgrass Evaluation Test at Las Cruces, New Mexico in 1986.

Entry	Summer color[1/]	Fall color[2/]
NM S-1	7.3	3.3
Common	6.5	5.5
Guymon	7.3	4.3
LSD (P=0.05)	0.7	1.7

1/Mean rating of four observations, where 1 is least green and 9 most green.
2/Single rating.

Table 10. Color rankings[1/] for NM S-1 as compared with Common and Guymon at several national Bermudagrass Test Sites in 1986.

Site	Month	Entry		
		NM S-1	Common	Guymon
Kansas Wichita	July	7.3	5.7	6.3
Oklahoma Stillwater	July	6.0	4.3	6.0
California Riverside	September	7.0	6.3	7.0
Maryland Beltsville	October	3.0	3.0	4.3
North Carolina Raleigh	September	7.0	5.3	6.0
	October	6.0	5.3	6.7
	November	2.3	2.0	3.0

[1/]Ratings based on visual estimates where 1 is least and 9 most green.

Table 11. Turfgrass quality ratings[1/] of NM S-1 as composed to Common and Guymon in 1984 Strain Test at Las Cruces, New Mexico.

Entry	Turfgrass Quality		
	Spring[2/]	Summer[3/]	Fall[4/]
NM S-1	5.7	5.4	5.6
Common	3.0	4.7	4.8
Guymon	4.7	5.0	4.3
LSD (P=0.05)	1.6	1.0	1.2

[1/]Ratings based on visual estimates of turfgrass quality where 1 is poorest and 9 best.
[2/]Single rating in 1986.
[3/]Total of six ratings in 1985 and 1986.
[4/]Total of three ratings in 1984, 1985 and 1986.

Table 12. Turfgrass quality ratings[1/] for NM S-1 compared with Common and Guymon in National Bermuda Turfgrass Evaluation Test at Las Cruces, New Mexico in 1986.

Entry	Turfgrass quality
NM S-1	5.6
Common	4.9
Guymon	6.8
LSD (P=0.05)	0.8

[1/]Mean of 3 observations where 1 is poorest and 9 best.

Table 13. Turfgrass quality ratings[1/] for NM S-1 as compared to Common and Guymon at several National Bermudagrass Test sites in 1986.

Site	Entry		
	NM S-1	Common	Guymon
Kansas Wichita			
Oklahoma Stillwater	5.7	4.0	3.7
California Riverside	5.0	4.0	4.0
California Field station	4.3	3.6	4.0
Maryland Beltsville	6.0	5.0	6.0

[1/]Ratings based on visual estimates where 1 is lowest and 9 is highest overall turf quality.

ABSTRACT

HERITABILITY ESTIMATES FOR SELECTED TURFGRASS CHARACTERISTICS OF BERMUDAGRASS EVALUATED UNDER SHADE

BY

BRIAN NEIL COFFEY, B.S., M.S.
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No genetic estimates for chlorophyll content, visual color, general appearance, plot density, or clipping weight of bermudagrass, *Cynodon dactylon* (L.) Pers., evaluated under shade exists in the literature. As a result, the information to efficiently develop a breeding program to improve these characters was not available. The objectives of this investigation were to evaluate genetic variation among randomly selected parent clones and their polycross progenies, and to estimate heritabilities for five specific

turfgrass characteristics evaluated under shade in a field experiment at Las Cruces, New Mexico, in 1985 and 1986.

Parental clones exhibited highly significant differences for all evaluated characteristics, and the polycross progenies exhibited significant differences for chlorophyll concentration, visual color, and general appearance.

Broad-sense heritabilities were 0.90 or greater for all characteristics. Narrow-sense heritability estimates ranged from a low of 0.01 to a maximum of 0.71. Moderate-to-high narrow-sense heritabilities were calculated for visual color and chlorophyll content. The presence of non-additive gene action and / or other confounding effects was detected for several characteristics.

Chlorophyll content was highly correlated with visual color and general appearance, indicating that indirect selection for chlorophyll content may be performed efficiently via selection for visual color or general appearance in the field.

Large proportions of genetic variance were detected for chlorophyll concentration and visual color. These proportions, together with the moderate-to-high narrow-sense heritabilities calculated for these two characteristics, indicate that either phenotypic recurrent selection or mass selection techniques would be adequate to allow for efficient genetic gains to be realized. More intensive programs utilizing progeny testing would be required for plot density and clipping weight improvements since non-additive gene action is primarily conditioning these two characteristics.

This was completed in 1986, however, I did not furnish you an abstract

ABSTRACT

HERITABILITY ESTIMATES FOR SEED YIELD

AND COMPONENTS OF SEED YIELD

IN BERMUDAGRASS (Cynodon dactylon (L.) Pers.)

BY

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No genetic estimates for seed yield or components of seed yield in bermudagrass were reported in the literature. Consequently, the information was not available to design an efficient breeding program to improve those characteristics. Therefore, the objectives of this investigation were to evaluate genetic variation among randomly selected parental clones and their polycross progenies and to estimate heritabilities for seed yield and some components of seed yield.

Broad-sense, narrow-sense, and realized heritibilities were estimated using the polycross progeny method in a field experiment at Las Cruces, New Mexico, in 1983 and 1984. Genetic parameters of flowering characters were measured in a growth chamber and phenotypic correlations were calculated between data obtained in the

field and growth chamber.

Broad-sense heritabilities ranged from 0.47 to 0.98 for panicle density in 1983 and 1984. Estimates for seed yield were 0.77 and 0.90 for 1983 and 1984. Narrow-sense heritabilities were larger than 1.0 for seed yield and ranged from 0.15 to 0.94 for the other traits. Realized heritabilities ranged from -0.33 to 0.94 for panicle density in 1984 and branches per panicle in 1983. Realized heritabilities for seed yield were 0.46 and 0.37 in 1983 and 1984. Because narrow-sense estimates for seed yield were biased over 1.0, the realized heritability estimates were considered to be the most accurate. Heritabilities for characters measured in the growth chamber were not similar to heritabilities for those measured in the field.

Percent seed set was the single field trait best correlated with seed yield with r-values of 0.76 and 0.70 for 1983 and 1984. Multiple linear regression analyses of seed yield and components of seed yield measured in the field resulted in regression equations with R-values of 0.89 and 0.92 for 1983 and 1984. Multiple linear regression analyses of seed yield and components of seed yield measured in the growth chamber resulted in regression equations with R-values of 0.70 and 0.75 for 1983 and 1984.

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Heritability Estimates for Turfgrass Characteristics in Bermudagrass[1]

D. S. Wofford and A. A. Baltensperger[2]

ABSTRACT

No genetic estimates for turfgrass characteristics in bermudagrass, *Cynodon dactylon* (L.) Pers., are currently available in the literature. Therefore, the objectives of this investigation were to evaluate genetic variation among bermudagrass clones and their polycross progenies and to estimate heritability values for several turfgrass characteristics. Parental clones and polycross progenies were established in a randomized complete block design with four replications in 1981. The parental clones differed ($P < 0.01$) for all characteristics evaluated during 1981 and 1982. Polycross families differed ($P < 0.05$) for 13 of the 18 characters evaluated. Broad-sense heritability estimates for a single year ranged from 0.83 to 0.99. Narrow-sense heritability estimates based on the polycross family analyses ranged from 0.06 to 0.94. Heritability estimates from the parent-offspring covariance analyses ranged from 0.00 to 1.22. For a number of characters, additive genetic variation accounted for a significant portion of the total genetic variation. Data over a 2-year period were combined for leaf length and leaf width. Broad-sense heritability estimates were moderately high with values of 0.94 and 0.83 for leaf length and leaf width, respectively. Narrow-sense heritability values for leaf length and leaf width were 0.83 and 0.62 from the progeny analysis and 0.57 and 0.43 based on parent-offspring covariance, respectively. For characteristics which had moderate-to-high narrow-sense heritability values, breeding methods which involve no progeny testing should be suitable for genetic gain to be realized.

Additional index words: **Heritability, Genetic variation, *Cynodon dactylon* (L.) Pers., Turfgrass.**

BERMUDAGRASS, *Cynodon dactylon* (L.) Pers., is one of the most widely grown warm-season, perennial grass species in the southern United States. This grass is utilized both as turfgrass and as a forage crop. In New Mexico, bermudagrass is the most commonly utilized turfgrass species with over 7700 ha currently in use (7).

At present, numerous cultivars are commercially available (2). The vast majority of these cultivars are vegetatively propagated. This may be due to the increased uniformity attained through the use of a single genotype, the existence of economical vegetative planting methods and/or problems in fertility.

Kneebone (5) reported that genetic variability for color, leaf morphology, cold tolerance, winterhardiness, and other characteristics was available. Reinert et al. (8) demonstrated that variability for resistance to bermudagrass stunt mite, *Aceria cynodoniensis* (Hassan) Kiefer, was present among clones. Richardson et al. (9) found significant differences among bermudagrass clones for fertility and seed production. Harlan and de Wet (3) concluded that intraspecific and interspecific variability for fertility and seed production was due to population fragmentation based on chromosomal behavior. They suggested that these meiotic irregularities were the result of cryptic factors such as translocations, inversions and deletions. These factors result in varying degrees of sterility in the progenies from matings between natural populations.

Several researchers have estimated heritability values for certain forage quality characteristics in bermudagrass species (1,6). There are, however, no known heritability estimates documented for turfgrass characteristics. These estimations would be advantageous in designing a breeding program to improve a seeded population.

The objectives of this study were to determine if genetic variability for numerous turfgrass characteristics existed among parental clones and their polycross progenies and to estimate heritability values for these characteristics.

MATERIALS AND METHODS

Eight bermudagrass clones were used as parents in this investigation. All clones used were typical of the tetraploid bermudagrass type. The clones were chosen from a nursery of turf-type bermudagrasses which originated from material obtained from 10 agricultural experiment stations in the United States. The parental clones were established in a polycross mating block with 10 replications in 1979 at the Plant Science Research Center near Las Cruces, NM. Sixteen clones were initially chosen to serve as parental material; however, eight clones failed to produce sufficient seed for progeny testing. These clones were subsequently removed from the polycross block prior to progeny seed production. Seed was harvested in 1980 and bulked within parental entries.

Progenies were seeded in a commercial soil medium in plastic containers (3.8 cm × 21.5 cm) in the greenhouse on 29 Apr. 1981, and were grown under favorable conditions for 9 weeks. On 1 July the polycross progenies and parental sprigs were established in a field experiment at the Plant Science Research Center. The experimental design used was a randomized complete block with four replications. Plots were 1.22 × 1.52 m in dimension. Either 20 progeny seedlings or 20 parental sprigs were established on 0.3 m spacings in each plot. All experimental units received the following management procedures throughout the study: 0.9 kg of N per month during the growing season, clipping to a height of 2.54 cm every 2 weeks and flood irrigation once a week to avoid stress.

The characteristics examined, year of evaluation, and method of data collection are shown in Table 1. Due to insufficient growth in some entries, fewer characters were evaluated in 1981 than 1982. Data for 1981 were collected from 27 July to 15 September. In 1982, visual ratings were made in July, August, and September. Values for the three time periods were averaged as subsamples in time for all visually rated characteristics except color. Color data were analyzed separately because greenness of bermudagrass foliage is affected by distinctly different environmental factors throughout the growing season. The measured regrowth and clipping weight data were collected following each visual rating. Data for leaf length, leaf width, and stem internode length were taken from 28 July to 14 September.

The basic statistical design utilized for a single year's data was a randomized complete block with four replications.

[1] Journal article 1031, Agric. Exp. Stn., New Mexico State Univ., Las Cruces, NM 88003. Received 10 Feb. 1984.

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Data combined over the 2-year period were analyzed using a split-plot in time analysis (10). Both the analyses of variance and analysis of covariance were computed using whole plot values. Expected mean squares and mean products were based on a random effects model. Variance components and covariance components were estimated from linear functions of the mean squares and mean products, respectively, and standard errors for the mean squares were calculated according to Kempthorne (4).

Since the parents were clones, genetic variation among parents would estimate the total genetic variation. Therefore, genetic variance component estimates from clonal analyses were used to calculate broadsense heritability values (H_b). The genetic variation among polycross or half-sib families would predominately measure additive genetic variation, thus genetic variance component estimates were utilized to calculate narrow-sense heritabilities (H_n).

Broad sense and narrow-sense heritabilities based on the results of a single year were calculated as follows:

$$H_b = \sigma^2_C/[\sigma^2_C + (\sigma^2_E/r)]$$

$$H_n = \sigma^2_P/[\sigma^2_P + (\sigma^2_E/r)]$$

where,

σ^2_C, σ^2_P = variance components due to parents and polycross families, respectively;

σ^2_E = variance components due to genotype × replication interaction which were from the ANOVA for parental clones in calculating H_b and from the ANOVA for polycross families in calculating H_n; and

r = number of replications

Broad-sense and narrow-sense heritabilities for the combined data were calculated using the following formulas:

$$H_b = \sigma^2_C/[\sigma^2_C + (\sigma^2_{CY}/y) + (\sigma^2_{CR}/r) + (\sigma^2_E/ry)]$$

$$H_n = \sigma^2_P/[\sigma^2_P + (\sigma^2_{PY}/y) + (\sigma^2_{PR}/r) + (\sigma^2_E/ry)]$$

where,

σ^2_C, σ^2_P = variance components due to parental clones and polycross families, respectively;

σ^2_{CY}, σ^2_{PY} = variance components due to parental clones × year and polycross families × year interactions, respectively;

σ^2_{CR}, σ^2_{PR} = variance components due to parental clones × replication and polycross family × replication interaction, respectively;

σ^2_E = variance components due to genotype × replication × year interaction which were estimated from the parental ANOVA in calculating the H_b and from the progeny ANOVA in calculating H_n; and

r, y = number of replications and years, respectively.

The parent-offspring covariance analyses were utilized

Table 1. Year and method of evaluation for turfgrass characteristics of parental clones and polycross progenies at Las Cruces, New Mexico.

Year	Characteristic	Method of evaluation†
1981	Density	A—1 least dense, 9 most dense
	Leaf length	B—fully expanded leaf (mm)
	Leaf width	B—fully expanded leaf (mm)
	Stolon internode length	B—fully elongated internodal distance (mm) of prostrate stem
	Vigor	A—1 least vigorous, 9 most vigorous
1982	Clipping weight	C—grams per plot
	Color	A—1 least green, 9 most green
	Density	A—as previously stated
	General appearance	A—1 worst appearance, 9 best appearance
	Mite resistance	A—1 least resistance, 9 most resistance based on reduced stem internodal regions
	Leaf length	B—as previously stated
	Leaf width	B—as previously stated
	Regrowth	A—1 least regrowth, 9 most regrowth two weeks after clipping
	Regrowth	D—regrowth (mm) two weeks after clipping
	Seedhead production	A—1 fewest seedheads, 9 most seedheads
	Stem internode length	B—fully elongated internodal distance (mm) of upright stem

† A. Visual rating with a scale from 1-9. B. Plot value was average of 15 random samples per plot. C. 87% of plot harvested after 2 weeks regrowth. D. Plot value was average of five random samples per plot.

Table 2. Means and ranges of means (over replications) for visually rated characteristics in parental clones and polycross families of bermudagrass.

		Parent		Progeny	
Characteristic	Year	Mean ± SE†	Range	Mean ± SE	Range
Color I	1982	5.72 ± 0.47	4.27-7.50	5.84 ± 0.79	5.25-7.75
Color II	1982	5.66 ± 0.54	2.50-8.50	4.84 ± 0.39	3.00-6.75
Color III	1982	4.59 ± 0.48	1.50-7.75	4.16 ± 0.57	2.25-7.00
Density	1981	4.56 ± 0.57	1.75-8.00	4.88 ± 0.54	3.75-6.00
Density	1982	5.69 ± 0.47	2.75-8.00	6.91 ± 0.46	5.50-8.00
General appearance	1982	3.63 ± 0.45	1.50-5.50	4.38 ± 0.40	3.25-6.25
Mite resistance	1982	2.63 ± 0.27	1.00-7.00	4.81 ± 0.71	3.50-6.75
Regrowth	1982	3.94 ± 0.49	1.50-7.25	4.88 ± 0.53	3.75-6.00
Seedhead production	1982	4.88 ± 0.42	1.00-9.00	4.06 ± 0.43	3.00-5.75
Vigor	1981	4.72 ± 0.48	1.75-8.50	5.34 ± 0.54	4.00-6.75

† Standard error of genotype mean in the analysis of variance.

Table 3. Means and ranges of means (over replications) for measured characteristics in parental clones and polycross families of bermudagrass.

		Parent		Progeny	
Characteristic	Year	Mean ± SE†	Range	Mean ± SE	Range
Clipping weight (g)	1982	60.79 ± 4.75	10.25-110.03	65.88 ± 5.94	51.50-79.70
Leaf length (mm)	1981	16.30 ± 0.92	10.82-24.80	0.61 ± 0.90	17.85-22.85
	1982	17.96 ± 0.54	12.95-24.65	20.38 ± 0.91	18.23-22.93
	Combined	17.13 ± 0.53	11.89-24.73	20.50 ± 0.71	18.04-22.89
Leaf width (mm)	1981	2.39 ± 0.05	1.96-2.83	2.50 ± 0.07	2.35-2.64
	1982	2.47 ± 0.05	2.23-2.68	2.45 ± 0.04	2.35-2.59
	Combined	2.43 ± 0.04	2.10-2.76	2.48 ± 0.04	2.35-2.62
Regrowth (mm)	1982	34.09 ± 1.61	8.89-49.21	44.61 ± 1.27	39.69-48.58
Stem internode length (mm)	1982	6.03 ± 0.16	5.32-7.27	6.23 ± 0.25	4.73-7.42
Stolon internode length (mm)	1981	21.69 ± 0.95	14.89-28.73	22.17 ± 0.59	18.67-25.33

† Standard error of genotype mean in the analysis of variance.

to calculate narrow-sense heritability values using the following formulas:

$$H_{PO} = 2b_G = 2[\sigma_{PO}/[\sigma_C^2 + (\sigma_E^2/r)] \text{ for a single year}$$

and

$$H_{PO} = 2b_G = 2\,[\sigma_{PO}/[\sigma_C^2 + (\sigma_{CY}^2/y) + (\sigma_{CR}^2/r) + (\sigma_E^2/ry)] \text{ for the combined data}$$

where,

σ_{PO} = genetic covariance between parent and offspring; and other components are as previously described.

RESULTS AND DISCUSSION

Means and ranges of means for clones and progeny families are shown in Tables 2 and 3. The ranges of the polycross progenies fall within the ranges of the parental clones for eight of the 10 visually rated characters and seven of the eight measured characters. A similar response was observed for the combined data of leaf length and leaf width.

Genetic variation was highly significant among clones for all characteristics evaluated (Tables 4 and 5). These results indicate that the level of performance for all characters, regardless of the type of gene action involved, could be altered using breeding methods. Genetic variation among polycross families was significant for six of the 10 visually rated characters and seven of the eight measured characters. Therefore, a considerable portion of the total genetic variation for these 13 characters is of an additive nature. Breeding methods that capitalize on additive genetic variation should result in improvement for these characteristics.

The genetic variance component estimates from the parental analyses for visually rated characteristics were twice or approximately twice their standard error. In most cases, the genetic variance component estimates from the polycross family analyses were

Table 4. Estimates of variance components and their standard errors for visually rated characteristics in parental clones and polycross families of bermudagrass.

Characteristic	Year	Genotype	$\sigma_G^2 \pm$ SE	$\sigma_E^2 \pm$ SE	σ_{PO}
Color I	1982	Parent	1.11 ± 0.63**	0.89 ± 0.26	0.12
		Progeny	0.04 ± 0.36	2.47 ± 0.73	
Color II	1982	Parent	5.42 ± 2.69**	1.17 ± 0.35	1.58
		Progeny	1.35 ± 0.71**	0.61 ± 0.18	
Color III	1982	Parent	5.00 ± 2.47**	0.92 ± 0.27	3.62
		Progeny	2.39 ± 1.34**	1.78 ± 0.53	
Density	1981	Parent	3.07 ± 1.60**	1.28 ± 0.38	1.11
		Progeny	0.24 ± 0.27	1.18 ± 0.35	
	1982	Parent	3.55 ± 1.77**	0.88 ± 0.26	0.16
		Progeny	0.39 ± 0.29*	0.86 ± 0.26	
General appearance	1982	Parent	2.69 ± 1.36**	0.80 ± 0.24	0.06
		Progeny	0.84 ± 0.47**	0.63 ± 0.19	
Mite resistance	1982	Parent	4.66 ± 2.23**	0.30 ± 0.09	−0.25
		Progeny	0.43 ± 0.46	2.04 ± 0.60	
Regrowth	1982	Parent	4.07 ± 2.04**	0.97 ± 0.29	−0.33
		Progeny	0.33 ± 0.31	1.11 ± 0.33	
Seedhead production	1982	Parent	6.95 ± 3.36**	0.70 ± 0.21	0.43
		Progeny	0.97 ± 0.55**	0.73 ± 0.22	
Vigor	1981	Parent	3.88 ± 1.94**	0.94 ± 0.28	2.32
		Progeny	0.73 ± 0.49*	1.16 ± 0.34	

*,** Mean square associated with variance component estimate was significant at the 0.05 and 0.01 probability levels based on analysis of variance *F tests.*

Table 6. Broad-sense (H_b) and narrow-sense (H_n and H_{PO}) heritability estimates for turfgrass characteristics in bermudagrass.

Method of evaluation	Characteristic	Year	H_b	H_n	H_{PO}
Visual	Color I	1982	0.83	0.06	0.12
	Color II	1982	0.95	0.90	0.48
	Color III	1982	0.96	0.84	1.22
	Density	1981	0.91	0.49	0.51
		1982	0.94	0.64	0.07
	General appearance	1982	0.93	0.84	0.04
	Mite resistance	1982	0.98	0.46	0.00†
	Regrowth	1982	0.94	0.54	0.00†
	Seedhead production	1982	0.98	0.84	0.11
	Vigor	1981	0.94	0.71	0.97
Measured	Clipping weight	1982	0.98	0.64	0.04
	Leaf length	1981	0.98	0.77	0.52
		1982	0.99	0.68	0.62
		Combined	0.94	0.83	0.57
	Leaf width	1981	0.98	0.35	0.45
		1982	0.88	0.72	0.63
		Combined	0.83	0.62	0.43
	Regrowth	1982	0.99	0.79	0.16
	Stem internode length	1982	0.96	0.92	0.14
	Stolon internode length	1981	0.96	0.94	0.81

† Negative genetic mean product component.

Table 5. Estimates of variance components and their standard errors for measured characteristics in parental clones and polycross families of bermudagrass.

Characteristic	Year	Genotype	$\sigma_G^2 \pm$ SE	$\sigma_E^2 \pm$ SE	σ_{PO}
Clipping weight	1982	Parent	1317.31 ± 631.61**	89.86 ± 26.50	28.71
		Progeny	62.40 ± 47.19*	141.00 ± 41.60	
Leaf length	1981	Parent	34.48 ± 16.65**	3.35 ± 0.99	9.77
		Progeny	2.68 ± 1.66**	3.27 ± 1.81	
	1982	Parent	20.30 ± 9.71**	1.18 ± 0.35	6.65
		Progeny	1.81 ± 1.27*	3.35 ± 0.99	
Leaf width	1981	Parent	0.091 ± 0.044**	0.009 ± 0.003	0.02
		Progeny	0.003 ± 0.004†	0.019 ± 0.006	
	1982	Parent	0.021 ± 0.011**	0.011 ± 0.003	0.01
		Progeny	0.004 ± 0.003*	0.007 ± 0.002	
Regrowth	1982	Parent	211.03 ± 100.7**	10.36 ± 3.06	17.97
		Progeny	5.89 ± 3.56**	6.41 ± 1.89	
Stem internode length	1981	Parent	0.60 ± 0.29**	0.11 ± 0.03	0.05
		Progeny	0.69 ± 0.35**	0.26 ± 0.08	
Stolon internode length	1981	Parent	19.53 ± 9.64**	3.64 ± 1.07	9.41
		Progeny	5.40 ± 2.70**	1.41 ± 0.42	

*,** Mean square associated with variance component estimate was significant at the 0.05 and 0.01 probability levels based on analysis of variance *F tests.*
† Mean square associated with genetic variance component was significant at the 0.10 probability level based on analysis of variance *F tests.*

Table 7. Estimates of variance components and their standard errors from combined analysis for leaf length and leaf width in parental clones and polycross families of bermudagrass.

Characteristic	Genotype	$\sigma^2_G \pm$ SE	$\sigma^2_{GY} \pm$ SE	$\sigma^2_{GR} \pm$ SE	$\sigma^2_E \pm$ SE	σ_{PO}
Leaf length	Parent	25.05 ± 12.51**	2.34 ± 1.38**	−0.01 ± 0.22†	2.28 ± 0.67	8.07
	Progeny	2.47 ± 1.38**	−0.16 ± 0.23	0.99 ± 0.67	2.04 ± 0.60	
Leaf width	Parent	0.042 ± 0.024**	0.015 ± 0.008**	0.002 ± 0.002	0.008 ± 0.003	0.013
	Progeny	0.006 ± 0.003*	−0.002 ± 0.001	0.001 ± 0.003	0.012 ± 0.004	

*,** Mean square associated with variance component estimate was significant at the 0.05 and 0.01 probability levels based on the analysis of variance *F tests*.

† Negative variance component estimates were assumed to be zero in calculating heritability values.

larger than their standard error. One would expect the variance component estimate from the progeny analyses to be smaller than those from the parental analyses since the progeny component was used to estimate only the additive portion of the total genetic variation. The progeny estimate was indeed lower than the parental estimate for all visually rated characters.

The total genetic variance component estimates for seven of the eight measured characters were at least twice their standard error. For the exception, leaf width 1982, the variance component estimate was approximately twice the standard error. Additive genetic variance component estimates were all larger than their standard error except for leaf width 1981. As expected, additive genetic variance component estimates for all characteristics were smaller than their respective total genetic variance component estimates.

Heritability values for both visually rated and measured characteristics are shown in Table 6. In general, all broad-sense heritability values (H_b) were high with a range from 0.83 to 0.99. Narrow-sense heritabilities (H_n) ranged from a low of 0.06 to a high of 0.94. Overall, H_n estimates were moderate to high for all characters except Color I 1982. As expected, all H_n values were lower than their respective H_b values. The H_n estimates for those characteristics where significant genetic variation was not detected in the progeny ANOVA are meaningless. Narrow-sense heritability estimates based on the parent-offspring covariance were approximately equal to estimates from the progeny analyses for five of the 10 visually rated traits and five of the eight measured traits.

Research workers commonly use visual rating scales to evaluate turfgrass performance. Regrowth was examined using both visual ratings and measurements. For both methods, highly significant differences were detected among parental clones and similar H_b estimates were calculated (Tables 4, 5, and 6). Significant genetic variation was detected among the polycross families using measurements, however, no differences were detected using visual ratings. There was little agreement between narrow-sense heritability estimates from the progeny and covariance analyses.

Significant genetic variation was detected in the combined analyses among both parental clones and polycross families (Table 7). All genetic variance component estimates either approximated or exceeded twice their standard error. H_b estimates for both leaf length and leaf width were high with values of 0.94 and 0.83, respectively (Table 6). H_n values for leaf length and leaf width were 0.83 and 0.62, respectively. Both H_n estimates were lower than their respective H_b estimate. Narrowsense estimates from the parent-offspring covariance were 0.57 and 0.43 for leaf length and leaf width, respectively. These results indicate that genetic change for these two leaf characters should be possible using breeding methods which utilize additive genetic variation.

In conclusion, significant genetic variation was detected among parental clones and polycross families for numerous turfgrass characteristics. These results concur with earlier reports that variation exists in bermudagrass for several turfgrass characters (5,8). The performance of all characteristics evaluated should be improved using traditional breeding procedures. For many characters, there was agreement between narrow-sense estimates based on the polycross family analyses and the parent-offspring covariance analyses. For these characters, a large portion of the total genetic variation was of an additive nature. In these situations, mass selection should be an efficient method for the improvement of a seeded population.

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ABSTRACT

SELF-FERTILITY STUDY OF

TEN BERMUDAGRASS GENOTYPES

by

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Little information is available on the amount of self-fertility in bermudagrass (*Cynodon dactylon*), especially for parent clones used in the New Mexico State University turfgrass breeding program. Since selfing vs. crossing is important in the development of a seed-propagated cultivar, a better estimate of self-fertilization is needed.

Percent self-fertility of ten bermudagrass (*Cynodon dactylon* (L.) Pers.) genotypes with diverse geographical origin was estimated in a greenhouse experiment during the winter of 1985-1986 and in a field experiment during the summer of 1986 at Las Cruces, New Mexico.

Results indicated that the ten clones were low in self-fertility in both the greenhouse and field with

means ranging from 0.02-0.56% seed set from the combined locations. "Common," a heterozygous, open-pollinated cultivar, had a seed set of 13.7% under the same isolation and environmental conditions.

Floral characters, anthesis date, branches per panicle and florets per branch did not significantly correlate with seed set for the ten clones, while panicle densities had a low significant correlation with seed set ($r=0.27$). Pollen shed scores were significantly correlated with caryopsis number in the greenhouse ($r=0.67$), but not in the field. Total florets and caryopsis were significantly correlated ($P<0.01$) for clones NM-471, Texturf 10, NM-21-2 and G-10.

Germination percentages were low for the clones highest in seed set. Seedling survival rate for the ten clones was low and because of the low number of surviving plants no data are reported. Therefore, primarily because of low self-fertility for the ten bermudagrass genotypes evaluated, there would be little effect from selfed seed in polycross progeny or advanced generations.