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Executive Summary
to
USGA - GCSAA

Research Project: Breeding Improved Seeded Bermudagrass for Turf

Submitted By: Arden A. Baltensperger, Professor of Agronomy, NMSU
October 1986

Partially as a result of findings from two Ph.D. studies, approximately 22,000 progenies were established in the greenhouse in the spring of 1986. These plants were subsequently selected for turf quality characteristics in both the greenhouse and field. An attempt is being made to improve several experimental strains for turf quality seed yield.

Five experimental seeded strains from the New Mexico State University breeding program were entered in a National Bermudagrass Test administered from Beltsville, Maryland. These tests were established in many states in the South and along the transition zone. Results from those tests will be valuable to the breeding program in indicating breeding progress and in determining where continued selection pressure is needed.

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ANNUAL REPORT
to
USGA Green Section

Project Title: Breeding Improved Seeded Bermudagrass for Turf

Submitted By: Arden A. Baltensperger, Professor of Agronomy,
NMSU, October 1986

As in the past, this report briefly covers the total bermudagrass breeding program at NMSU without regard to funding source. Most of our research since the last annual report, has been greenhouse, lathhouse and field oriented. As part of this program the project leader made a bermudagrass collection trip to Australia which resulted in approximately 60 plants that appear to be tetraploid with good and somewhat different turfgrass characteristics that may be valuable to future crossing and selection. This trip was financed by a special NMSU travel grant.

Breeding Program for 1985-86:

Approximately 22,000 polycross and single cross progeny plants were established in the greenhouse and phenotypically selected for turf quality characteristics. Selections were made both in the greenhouse and later in the field. Phenotypic selection of one polycross was done for seed head formation at Yuma, Arizona. This represents the 2nd, 3rd or 4th cycle of recurrent selection for several strains.

A study of self fertility in relation to seed yield and crossing is near completion. Also data from a shade tolerance genetic study is being analysed. Both experiments will provide information on how best to breed for those characteristics.

Experimental seeded strains, from the NMSU program were evaluated at Las Cruces, NM in two separate experiments. The NMSU Bermudagrass Strain Test, in its' third year and the National Strain Test which was established in April 1986. Several of the NMSU seeded entries show some superiority to common bermudagrass for reduced clipping weight, improved color and improved general appearance. Stem intermode length and leaf length were significantly shorter on two of the NSMU seeded entries in the National Test.

Results from cooperators in the National Bermudagrass Test over the next two years should indicate if additional cycles of recurrent selection are needed on some of the NMSU experimental strains. Approximately eighteen cooperators in the bermudagrass area of the U.S. established the National Test in 1986.

The third breeding methodology study is near completion as part of this program. The attached heritability study of vegetative characteristics was published in 1986. A thesis on heritability of seed yield and seed yield components was completed in early 1986 and will be submitted for publication

this year. The third study is on the inheritance of shade tolerance and should be completed in December 1986. These studies have helped determine the present breeding strategy and hopefully will be the basis for more effective breeding of seeded turf type bermudagrasses.

We feel this bermudagrass breeding project contributes to "Minimal Maintenance Turfgrass Development" by attempting to make improvements in a species that is quite low in water use and has good drought tolerance. We are attempting to develop a seeded variety that requires less nitrogen fertilizer, that requires less mowing (under minimum maintenance) and that uses less water than presently available seeded varieties.

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:

$$H_b = \sigma_C^2/[\sigma_C^2 + (\sigma_E^2/r)]$$

$$H_n = \sigma_P^2/[\sigma_P^2 + (\sigma_E^2/r)]$$

where,

σ_C^2, σ_P^2 = variance components due to parents and polycross families, respectively;

σ_E^2 = 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:

$$H_b = \sigma_C^2/[\sigma_C^2 + (\sigma_{CY}^2/y) + (\sigma_{CR}^2/r) + (\sigma_E^2/ry)]$$

$$H_n = \sigma_P^2/[\sigma_P^2 + (\sigma_{PY}^2/y) + (\sigma_{PR}^2/r) + (\sigma_E^2/ry)]$$

where,

σ_C^2, σ_P^2 = variance components due to parental clones and polycross families, respectively;

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

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

σ_E^2 = 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:

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

and

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