Classification of St. Augustinegrass[1]

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ABSTRACT

St. Augustinegrass [*S. secundatum* (Walt.) Kuntze] varies genetically in many morphological and agronomic traits. The objective of this study was to classify a sample of St. Augustinegrass genotypes. By distinguishing natural groups, a classification would be useful in summarizing the genetic variation. A collection of *Stenotaphrum* genotypes was classified on morphological and performance traits from field plots and pots. Clustering was based on a standardized data set of 26 characters measured on 94 genotypes. Five groups of St. Augustinegrass were recognized from the cluster diagram. In order of distinctiveness and internal similarity, the groups included: Gulf Coast, Bitterblue, Dwarf, Roselawn-Floratam, and Miscellaneous. The mean coefficient of determination for 26 characters was 51%. Over 85% of the classified genotypes could be identified to a specific group by using a key. The taxonomic groups appeared to be natural and corresponded to several distinctive patterns, including geography, chromosome number, and adaptation. Economic characters such as rate of coverage, gray leafspot resistance, blueness of leaves, and overall size differed for various groups, and the classification can serve as a framework of orientation for a breeding program.

***Additional index words:* *Stenotaphrum secundatum*, Turf, Cultivars, Breeding, Numerical taxonomy.**

ST. Augustinegrass [*Stenotaphrum secundatum* (Walt.) Kuntze] is a widely distributed coastal pioneer in the tropics and subtropics. It has become an important turf and pasture grass in the southeastern coastal U.S. However, few studies have attempted to illuminate its history and intraspecific variation. Sauer (12) reported that an important cultivated group of St. Augustinegrass, the Cape deme, was used as a lawn grass in Natal by the year 1900. Other taxa of St. Augustinegrass have been recognized and cultivated under trade names (8). Although morphological comparisons of cultivated strains were made (4,9) and a chromosome study identified several ploidy levels (10), this information has not been incorporated into a classification.

The objective of this study was to classify a sample of St. Augustinegrass genotypes. The practical purpose of the classification was to orientate a breeding program. St. Augustinegrass varies genetically in many morphological and agronomic traits, but this variation is not strictly continuous. As we will demonstrate, there are a few natural genotype groups that explain most of the observed variation. By considering potentially important economic and/or adaptive traits, the classification should serve as a prospectus of beneficial genes.

MATERIALS AND METHODS

A collection of 169 genotypes of *Stenotaphrum* was studied. Each genotype consisted of a cultivar, numbered accession, seedling variant, or artificial mutation (5,11) that had been propagated from a single stolon cutting. Genotypes were transplanted into 2-gallon pots filled with Peelings® organic soil mix and were fertilized with Osmocote® 16-4-8, about 15 g per pot. One replication of each genotype was grown outdoors under full sunlight and irrigated daily. Plants were healthy but not luxuriant. The holding area was uniform and plants were uncrowded, so that location effects were judged to be minimal. Complete sets of morphological measurements were made at specific times. Characters measured were: leaf length, thickness, and width; internode length and thickness, both horizontal and vertical; length of peduncle, floriferous region, and total height above soil of terminal inflorescences; number of spikelets per inflorescence; number of racemes in the inflorescence and their distance

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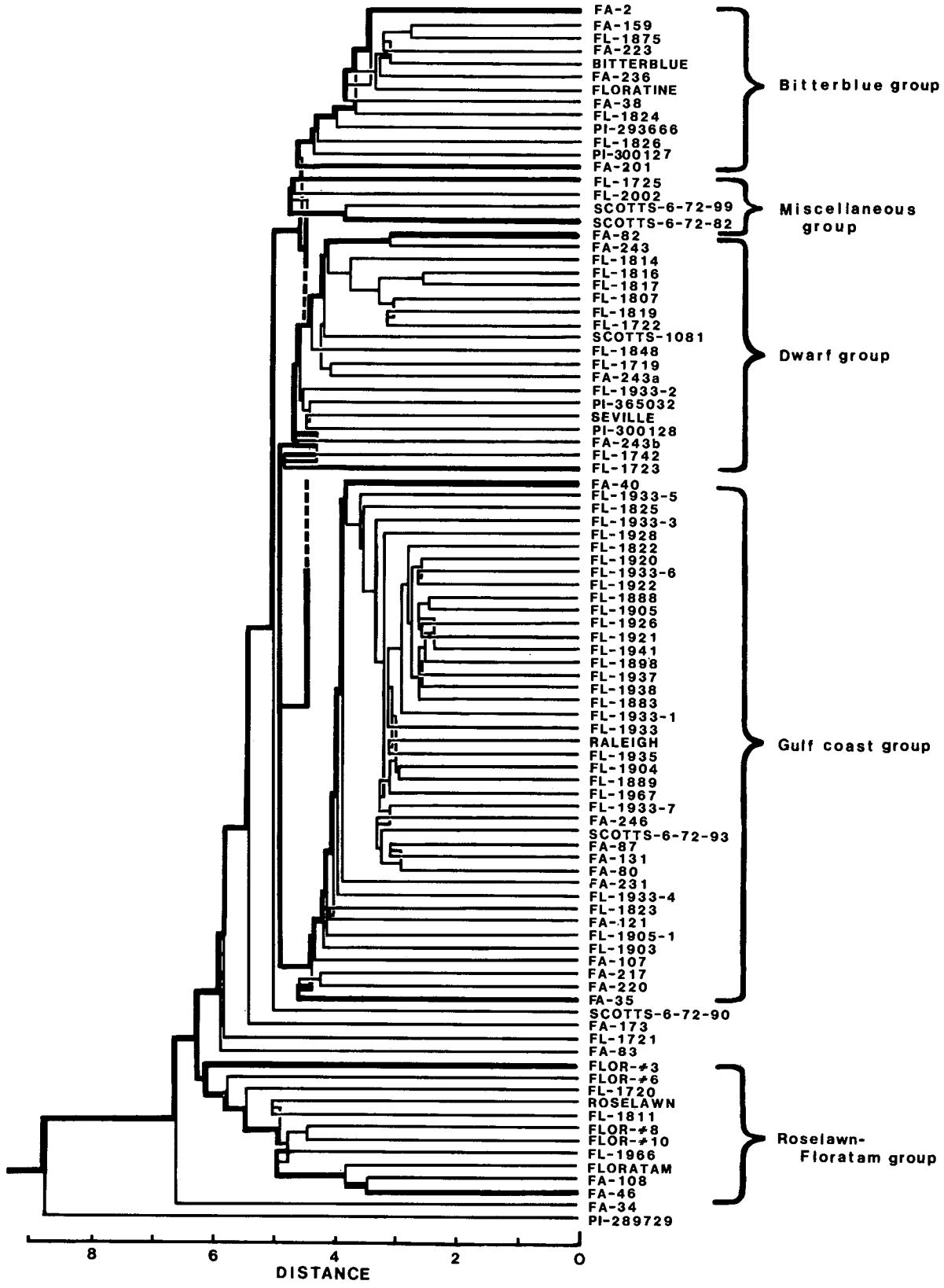

Fig. 1. Phenogram of 94 St. Augustinegrass genotypes, indicating group assignments. Branches that embrace the extreme limits of the groups have been drawn in heavy line. Small reversals in the branching pattern reflect the non-monotonicity of the clustering procedure used. Distance is standardized Euclidean distance.

Table 1. Sources of and group assignments for 94 St. Augustinegrass genotypes.

Source	Group						
	Bitter-blue	Gulf Coast	Dwarf	Roselawn-Floratam	Misc.	Other	Total
Exotic, non-U.S.	2	–	2	–	–	1	5
Southeastern U.S.							
Wild growing, Florida	–	–	3	2	1	1	7
Wild growing, Gulf Coast States	–	14	–	–	–	–	14
Cultivated, Gulf Coast	1	3	–	1	–	–	5
Other Gulf Coast	–	1	–	–	–	–	1
Breeding lines							
Hybrids and seedlings	4	12	3	1	2	3	25
Mutants	–	–	–	5	1	–	6
Other agronomic selections	4	10	10	–	–	1	25
Cultivars	2	1	1	2	–	–	6
Total	13	41	19	11	4	6	94

Table 2. Group means for distinguishing characters of St. Augustinegrass. Within group standard deviation is represented by 's.'

Character	Group					
	Bitter-blue	Gulf Coast	Dwarf	Roselawn-Floratam	Misc.	s
Internode thickness, vertical (mm)	2.56	2.22	2.11	2.68	2.25	0.24
Floriferous region length (mm)	64	62	66	99	93	11
Racemes in inflorescence (no.)	15	13	12	16	13	1
Distance between raceme nodes (mm)	3.7	4.1	4.5	5.7	6.2	0.6
Spikelet length (mm)	4.7	4.0	4.0	4.9	4.1	0.2
Glume length (mm)	0.31	0.43	0.35	0.44	0.35	0.07
Stolon redness†	5.7	4.3	5.8	6.3	4.4	0.5
Stigma color†	2.4	1.0	2.9	2.9	1.5	0.4
Anther color†	2.2	1.9	2.9	2.2	2.0	0.3
Blueness of leaves‡	3.0	1.8	1.6	2.5	1.6	0.4
Soil coverage, 7 mos. (%)	25	18	40	31	48	14
Gray leafspot incidence§	7.5	5.2	4.2	4.3	3.8	1.4
Chromosome number	30	18	18	18–32	18	–

† Anthocyanin ratings were: stolon redness in field plots, 3 = almost green, 8 = intense red; stigma color, 1 = white, 2 = bicolor, 3 = purple; anther color, 1 = cream to white, 2 = yellow or orange, 3 = orange to burgundy.

‡ Blueness of leaves, 1 = yellow-green to 3 = very blue-green, with a reflective sheen.

§ Gray leafspot incidence, 1 = no spots to 10 = devastated.

apart in the middle of the inflorescence; and the length of glumes and spikelets. Means of each character were based on five samples per genotype. Other characters evaluated from a single observation per plant were: colors of anther, stigma, and collar region at the base of the leaf blade, on a 1- to 3 scale based on level of intensity; and redness of stolons and leaf sheaths on a 1 to 10 scale.

A field planting of 143 of the 169 genotypes was subsequently established and maintained (6) and additional characters were evaluated. Genotypes in field plots were planted from six peat pots per plot and were arranged in a randomized complete block design, with two (and, in a few instances, four) replications. Measured characters were internode length and longest stolon length per plot 6 weeks after planting. Visual evaluations were determined for percent ground coverage both 5 and 7 months after planting; incidence of gray leafspot disease, on a 1 to 10 scale; redness of stolons; and blueness of leaves, on a 1 to 3 scale.

The data matrix consisted of a complete set of means of 26 characters that were obtainable from 94 of the genotypes (Table 1). Characters were standardized to a mean of zero and a standard deviation of one. Clustering of genotypes was performed using standardized scores as the basis for Euclidean distance coefficients. The clustering method used, BMDP program 2M (2), was an average linkage method, specifically the unweighted pair-group centroid method (13). The phenogram from cluster analysis was used as a guide to assigning genotypes to groups. Genotypes that branched off individually at considerable distance were not considered a part of any group. Major branches from the phenogram were recognized as taxonomic groups. Known genetic relationships were considered in determining what levels of branching to accept for purposes of grouping. Analysis of variance was performed on each character to determine which characters had the greatest proportion of variance determined by groups, and the strongest characters were chosen for a key to the groups. Several keys were tested for their effectiveness in sorting genotypes into the original groups using the original data. The most accurate key was retested using the original genotypes re-established in 3.8 liter (2 gallon) pots. An additional character, chromosome number, was determined for only 44 genotypes, and was also considered in evaluating the significance of the classification.

RESULTS AND DISCUSSION

Because of the clustering procedure used, the resulting phenogram was non-monotonic, that is, groups were often joined at a shorter distance than they were originally created (Fig. 1). Three major branches represented homogeneous groups: Gulf Coast group, Bitterblue group, and Dwarf group. On closer examination, one heterogeneous group deserved recognition, the Roselawn-Floratam group. The majority of the genotypes in this group were related either as mutant derivatives or as seedling descendants. ('Floratam' and FA-108 were seedlings of a 'Roselawn' progeny). Other genotypes were either very distant from one another and appeared as solitary branches, or were clustered with so few individuals that they may represent intermediate types (e.g., Miscellaneous group). One solitary genotype, PI-289729 was identified as the species *S. dimidiatum* (L.) Brongn. (J. D. Sauer, personal communication). Group assignments are presented by sources for the genotypes (Table 1). Considering the five groups as classes, along with the six unclassified genotypes, the classification explained from 17% of the total variation for stolon length, to 86% for stigma color. The mean coefficient of determination (r^2) for 26 characters was 51%.

A key to groups of St. Augustinegrass was:

Stigmas entirely white and distance between inflorescence nodes ≤ 5.7 mm; stolons not purple ..... *Gulf Coast group*

Stigmas usually purple or bicolor, rarely white with inflorescence internodes > 5.7 mm; stolons green to purple

- Leaves distinctly blue-green, with a reflective waxy sheen; spikelets generally long, > 4.4 mm
- Gray leafspot common, economically damaging in newly established areas, floral region generally ≤ 83 mm..... *Bitterblue group*
- Gray leafspot occasional to absent, floral region ≥ 86 mm..... *Roselawn-Floratam group*

Leaves green; spikelets ≤ 4.4 mm long
  Internodes > 70 mm long ..... *Roselawn-Floratam group*
  Internodes ≤ 70 mm long
    Distance between inflorescence nodes ≤ 5.6 mm; stems generally intense red ..... *Dwarf group*
    Distance between inflorescence nodes > 5.6 mm; stems green..... *Miscellaneous group*

Out of 88 genotypes that had been previously assigned to one of five groups (Fig. 1), 94% were accurately reassigned through the use of this key on the original data. Out of 69 genotypes available for reidentification, 86% were accurately reassigned.

Mean values for selected characters are presented (Table 2) and the groups are described below.

Gulf Coast Group. This is a very homogeneous group, with plant parts green, virtually unpigmented, stigmas white, stolons medium to narrow (2.0 to 2.4 mm in vertical thickness), and spikelets short (< 4.3 mm). Most Gulf Coast St. Augustinegrasses showed heavy feeding by sod webworm in a potted plant study (B.J. Center, unpublished observations). These plants were distributed primarily along the Gulf Coast of Texas and Louisiana, in cultivation and as a roadside weed at least as far northwest as San Antonio. Sites included areas abandoned from cultivation as turf for at least 5 to 10 or more years, such as old gasoline stations and missions. No accessions of the Gulf Coast Group occurred in collections from outside the USA. One cultivar, 'Raleigh', was classified in the Gulf Coast group. Eighteen out of 20 collections from along the Gulf Coast were clustered here (Table 1), along with 6 out of 6 selfed progeny from FL-1933, a Gulf Coast genotype.

Bitterblue Group. This group consists of plants with moderately thick (>2.35 mm) reddish stolons, bluish-green leaves, long (>4.4 mm) spikelets, and a high susceptibility to gray leafspot disease (7). This group appears to be synonymous with the "Cape deme" of Sauer (12), being approximately triploid ($2n \approx 30$) and sterile. (Most other St. Augustinegrasses are diploid, $2n=18$). Most Bitterblue collections were from Florida, but two accessions from Africa, PI-300127 and PI-293666 were in the Bitterblue group. 'Floratine' and the accession representing the trade type 'Bitterblue' were both classified in the Bitterblue Group. No wild growing accessions have been identified in this group. The trade type Bitterblue has better shade tolerance than other St. Augustinegrasses (3). The leaves are more horizontal, which may allow improved light interception in shady conditions, as well as shorter stature.

Dwarf Group. These are diminutive plants with internodes <2.2 mm thick; spikelets 3.8 to 4.1 mm long; and with a tendency to cover the soil rapidly. The soil covering ability may be due to an extensive branching habit. Partly as a result of this habit of growth, stolons were observed to pile up in a deep, spongy layer that made maintenance difficult. Dwarf St. Augustinegrasses were also observed to display heavy sod webworm damage in pots and in the field. Overall the Dwarves are most similar to the Gulf Coast Group in having smaller dimensions, but they share pigmentation and some floral similarities with the Roselawn Group. Pigmentation in the anthers of the dwarves is more intense than in any other group. The Dwarf group intergrades with the Miscellaneous group—experimental line FA-243 was classified as a Dwarf and its gamma ray derivative FL-2002 (5) was classified in the Miscellaneous group.

Roselawn-Floratam Group. This group consists of plants with long (generally > 60 mm) internodes, reddish leaves (especially the collar region), red stolons, and long floriferous regions (generally > 75 mm). The reddish tendency in the leaves of Floratam and its mutant derivatives is conspicuous when plants are subjected to cold stress or fertility deficiency. Otherwise these particular plants appear like plants of the Bitterblue group, but can be distinguished by thicker internodes (≥ 2.9 mm vertical) and resistance to gray leafspot (4). Floratam is known to have been derived from a Roselawn seedling (9). The Floratam phenotype is found sporadically only in cultivation or among breeding lines. The Roselawn phenotype is found growing in pastures and older lawns. One cultivated variety was present in this group, Roselawn which has been widely used as a forage grass in the Everglades region of southern Florida (1). An entirely wild growing collection (FL-2201) which keyed to the Roselawn-Floratam Group was obtained at East Cape Sable, which is a remote area at the southernmost point of the Florida peninsula. Material designated as 'Florida Common'—an undescribed trade name—also keys to this group.

Miscellaneous Group. Only four genotypes were placed in this group. They are similar to Dwarf genotypes, except for reduced pigmentation. Except for one plant known to be a mutant derivative, these plants probably represent inter-group hybrids. They show exceptional vigor in terms of rapid soil coverage and their inflorescences are very long.

CONCLUSIONS

St. Augustinegrass genotypes were classified into functional groups based in part on numerical techniques. The classification effectively represented agronomically selected materials including cultivars, artificial mutations, and seedlings (65% of the sample) and new collections, both cultivated and wild growing, from the southeastern U.S. (30% of the sample). Two groups, Gulf Coast and Bitterblue, were very discrete, whereas many other genotypes appear to represent continuous variation with recognizable extremes (e.g., Dwarf vs. Roselawn). Groups recognized here have several natural characteristics that reflect underlying trends with respect to: (a) geographic distribution (e.g., the localized distribution of the Gulf Coast Group), (b) ploidy level and resulting genetic isolation (most members of the Bitterblue group), and (c) important adaptive characteristics—e.g., tolerance to shade and susceptibility to gray leafspot disease in the Bitterblue group and high susceptibility to sod webworm in the Dwarf group and in the Gulf Coast group. These trends may reflect evolutionary relationships. By effectively using economic traits, the classification may offer a broader significance to those interested in the species for use as an ornamental. We expect that different improvement goals would be appropriate for different groups.

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