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A New Eastern Gamagrass Cultivar for the Southern United States[1]

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ABSTRACT

In 2003, the USDA Natural Resources Conservation Service (NRCS) Jamie L. Whitten Plant Materials Center, Coffeeville, Mississippi, will be releasing a new cultivar of eastern gamagrass [*Tripsacum dactyloides* (L.) L.] for forage and biomass production, soil stabilization, and water quality and wildlife habitat improvement. The cultivar, NRCS accession 9062680, will be named Highlander. The source material for this cultivar was collected in Montgomery County, Tennessee. Chromosome counts indicate that it is a tetraploid ($2n = 72$). Highlander was tested at various locations throughout the southeastern and south central United States and it provided average annual dry matter (DM) forage yields of 16 456 kg ha^{-1} on a 45-day cutting schedule. Tests at Coffeeville have shown potential DM yields of 13 850 kg ha^{-1} when plants were cut once annually for bioenergy fuel production. This cultivar has shown resistance to a devastating root and crown rot that killed mature plants of other eastern gamagrass accessions at Coffeeville. Tentative identification of the causal organisms showed that species of *Pythium* and *Rhizoctonia* were present and may have acted together as a disease complex. Highlander seed should be available on the commercial market for the 2005 planting season.

INTRODUCTION

Eastern gamagrass is a warm-season perennial grass, native to the eastern United States and the southern Great Plains, that has great potential for use as a forage (Horner et al., 1985) and for other conservation uses (Dewald et al., 1996). The desirable characteristics of this grass generated a great deal of interest from many agricultural researchers, especially those in the USDA, Natural Resources Conservation Service (NRCS) Plant Materials Program. The cultivars of eastern gamagrass that are most widely available in the commercial seed trade are 'Pete' or PMK-24, released by the NRCS Plant Materials Center (PMC) in Kansas, from germplasm collected in Kansas and Oklahoma (NRCS, 2002) and 'Iuka IV', from a similar collection location as Pete. Two cultivars recently released by the East Texas PMC, 'Jackson' and 'Medina', are not as well established in the seed trade. Other local germplasm sources have also been released by various PMCs for increase or further study (NRCS, 2002).

The Jamie L. Whitten PMC conducted an initial evaluation of 73 eastern gamagrass accessions from 1992 to 1994 and selected 9062680 based on its superior vigor, growth form, and

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disease resistance (Snider, 1995). This accession was collected in Montgomery County, Tennessee on the grounds of Fort Campbell. It is a tetraploid ($2n = 72$) (Chet Dewald, personal communication). This accession will be released in 2003 under the name 'Highlander'. This paper provides a summary of previous and current research studies conducted using 9062680 that support the release and aid in the development of management guidelines for this plant.

Forage Yields

Testing at the Jamie L. Whitten PMC near Coffeeville from 1996 to 1998 compared forage yields of 9062680 to 'Tifton 44' bermudagrass [*Cynodon dactylon* (L.) Pers.] and 'Alamo' switchgrass (*Panicum virgatum* L.). Bermudagrass, an introduced grass, is a primary forage species in the Southeast. All species were harvested on both a 30 and 45-day clipping regime. Although native grasses such as eastern gamagrass and switchgrass require an increased period of regrowth between clippings, both regimes were applied to all species to avoid favoring either the native or introduced species. When averaged over the three years, eastern gamagrass clipped at 45 days had higher yields than bermudagrass or switchgrass (Table 1). Stands in the eastern gamagrass 30-day plots began to decline by the second year of the study and yields were severely reduced in 1998. Forage quality values for eastern gamagrass vary between years and clippings, with the earliest clippings generally having the highest quality. The average quality estimates (Table 2) would seem to indicate that 9062680 is a fair to poor quality forage; however, *in-vitro* dry matter digestibility (IVDMD) for these samples has been determined to be in the low 60s (Joel Douglas, personal communication). Wright et al. (1983) found IVDMD values ranging from the mid 40s to the lower 70s for the five eastern gamagrass accessions and clipping dates they tested.

Table 1. Influence of clipping frequency on season total dry matter yield of 3 warm season grasses, 1996-1998, Coffeeville, Mississippi. (Adapted from Edwards, 2000.)

	Year			
Frequency	1996	1997	1998	Mean
9062680 Eastern Gamagrass				
	kg ha^{-1}			
30 day	14 004	14 709	4155	10 957
45 day	11 613	16 423	13 819	13 952
LSD (0.05)	NS†	NS	2505	2821
'Tifton 44' Bermudagrass				
30 day	12 959	11 457	11 816	12 078
45 day	12 433	8861	12 173	11 155
LSD (0.05)	NS	1796	NS	777
'Alamo' Switchgrass				
30 day	6368	6361	9633	7454
45 day	3508	8871	13 787	8722
LSD (0.05)	1109	2146	1454	1046

† Not significant.

Table 2. Average forage quality estimates of three warm season grasses clipped on 30 and 45 day frequencies from 1996-1998 at Coffeeville, Mississippi. (Adapted from Edwards, 2000.)

	9062680 Eastern Gamagrass		'Tifton 44' Bermudagrass		'Alamo' Switchgrass	
	30-day	45-day	30-day	45-day	30-day	45-day
	-------------	-------------	-------------	%	-------------	-------------
CP†	10 (8-12)	10 (6-11)	9 (6-12)	7 (5-9)	10 (7-13)	8 (6-10)
ADF‡	38 (36-41)	39 (37-41)	36 (33-40)	38 (35-39)	35 (33-38)	37 (33-40)
NDF§	68 (66-70)	70 (68-72)	71 (70-74)	73 (71-75)	68 (65-71)	69 (65-71)

† Crude protein. Numbers in parentheses are the range of values over all clippings in the study.

‡ Acid detergent fiber. Numbers in parentheses are the range of values over all clippings in the study.

§ Neutral detergent fiber. Numbers in parentheses are the range of values over all clippings in the study.

An inter-center strain trial, testing superior eastern gamagrass accessions from PMCs in the southern US, was initiated to determine the best candidates for release. A total of 13 accessions were planted at six PMCs and plots were harvested from 1996-1998 on a 45-day clipping regime. Data from the PMC at Americus, Georgia shows that 9062680 had the highest average yield over the study period (Table 3). It also was among the highest yielding at all sites except Knox City, Texas and Brooksville, Florida, which were the two geographic extremes in the trial (Douglas et al., 2002a). Performance of many of these accessions at the Jamie L. Whitten PMC was quite different (Table 3). The three accessions with a single asterisk that are not footnoted were those provided by the Florida PMC ; they did not survive the winter following the first harvest year at either Coffeeville or Booneville, Arkansas. Accession 9043762, from the East Texas PMC in Nacogdoches, died early from a disease that, during the following winter, killed or damaged all accessions except 9062680 so severely that no further harvests were possible at the Coffeeville location.

Table 3. Average dry matter yield of 13 eastern gamagrass accessions from 1996-1998 at six locations. (Adapted from Douglas et al., 2000a.)

Accession	Booneville, AR	Knox City, TX	Nacogdoches, TX	Coffeeville, MS	Americus, GA	Brooksville, FL
	-------------	-------------	-------------	kg ha^{-1}	-------------	-------------
9062680	14 383	11 155	12 722	18 065	19 133	7522
434493	12 830	13 682	8172	14 041†	18 616	12 898
9043629	9032	8120	14 448	12 121†	12 858	7398
9043740	7930	*	14 492	12 427†	19 049	3201
9043762	13 324	16 423	11 724	*†	16 812	9967
9055975	*	*	2715	*	7455	10 957
9059213	*	2820	9179	*	14 791	13 306
9059215	*	3533	6799	*	16 579	15 130
9058465	11 436	11 269	11 823	15 653†	16 158	9405
9058495	13665	12 553	10 261	18 436†	14 508	*
9058569	9214	8013	4742	10 626†	7204	*
9062708	11 625	8588	10 691	15 359†	18 040	8158
9066165	13 707	13 083	11 042	14 724†	18 810	5942
LSD (0.05)	2903	3586	7132	‡	2940	5969

* Indicates that plants died after the first year that harvests were taken.

† Plants could not be harvested in 1998 or 1997 and 1998 (9043762 only) because they succumbed to disease.

‡ Because this column contains both two-year and three-year yield averages, no LSD was determined.

This disease killed large, established clumps of the susceptible accessions. When the diseased plants were dug and examined, the cortex of the roots sloughed off, leaving the stele, which is a symptom typical of *Pythium* spp. The cool, wet winters and fairly heavy soils at Coffeeville provide ideal conditions for development of water molds. Tests also showed that *Rhizoctonia* spp. was present. The two organisms may have been acting together as a complex or separately. It is suspected that the regular clipping during the inter-center strain trial may have increased susceptibility to this disease. The fact that plants of 9062680 showed no symptoms in this or other trials at the Jamie L. Whitten PMC where additional gamagrass accessions were affected indicate that it likely possesses resistance to this disease. This disease occurrence, although only noted at a single location in the trial, does indicate the need for further consideration of pest problems and appropriate management options before eastern gamagrass can achieve its potential as a forage crop.

Additional research on forage production and management of this accession is being conducted at the Jamie L. Whitten PMC and other locations. Small plot plantings were made at four sites in Mississippi in 1999 to compare 9062680 to the commercially available eastern gamagrass cultivars PMK-24, and Jackson (accession 9043740). The data presented in Table 4 represents only a single year's harvest at the PMC and at the Prairie Research Unit in Prairie and is therefore highly preliminary. Yields were not taken in 2001 at Wiggins, in the southern part of the state, or from the Brown Loam Experiment Station in Raymond in southwest central Mississippi. The highest yielding eastern gamagrass accessions were 9062680 at Coffeeville and Jackson at Prairie but the differences were not significant. Jackson was one of the accessions that proved to be susceptible to the disease problem noted previously. Yield response of 9062680 to nitrogen fertility is being studied in plots located at the Jamie L. Whitten PMC, the Prairie Research Unit, and Mississippi State University at Starkville. Annual N rates used are 0, 135, 269, 404, and 538 kg ha^{-1}. Results from this study are presented elsewhere in these proceedings (Douglas et al. In Press). Research is also being conducted to determine if 9062680 can be used as an alternative to corn (Zea mays L.) as a silage crop. Plots of 9062680 and corn were planted at the North Mississippi Branch Experiment Station in Holly Springs and at the Coastal Plain Experiment Station in Newton, Mississippi. Data on silage production and quality were collected in 2002, but analysis had not been completed at the time this manuscript was prepared.

Table 4. Season total yield of 3 eastern gamagrass ecotypes at Coffeeville, Mississippi and Prairie, Mississippi in 2001. (Adapted from Douglas et al., 2002.)

Accession	Coffeeville	Prairie
	--------kg ha^{-1}--------	
9062680	13 812	16 178a†
Pete (PMK-24)	10 981	11 590b
Jackson (9043740)	12 424	18 836a

† Yields in columns followed by different letters are significantly different at $P<0.05$.

Other Uses

Eastern gamagrass 9062680 is currently being tested for its potential to uptake nutrients from poultry litter applications. The study is being conducted at the Jamie L. Whitten PMC and at the North Mississippi Branch Experiment Station. Other species receiving similar poultry litter applications are 'Alamo' switchgrass, 'Summerall 007' bermudagrass, Johnsongrass [*Sorghum halepense* (L.) Pers.], and 'Pensacola' bahiagrass (*Paspalum notatum* Fluegge). In 2001 at the Coffeeville location, Johnsongrass was able to remove significantly more phosphorus than 9062680 (Table 5). There were no differences in any other parameter measured at either location. Additional testing is required to determine if 9062680 might be an acceptable plant for this use.

Table 5. 2001 Season total yield, P_2O_5, and N uptake of warm season grasses receiving 294 kg/ha N and 497 kg/ha P_2O_5 from poultry litter at Coffeeville (COF) and Holly Springs (HS), Mississippi. (Adapted from Douglas et al., 2002.)

Species	Yield		P_2O_5 uptake		N uptake	
	COF	HS	COF	HS	COF	HS
	kg ha^{-1}					
9062680 eastern gamagrass	11 080	6441	49	34	143	64
'Alamo' switchgrass	10 466	7922	41	36	137	85
'Summerall 007' bermudagrass	8547	4328	55	28	86	47
Johnsongrass	10 790	5083	67	26	143	47
'Pensacola' bahiagrass	-------	4681	---	28	----	58
LSD (0.05)	NS†	NS	12	NS	NS	NS

† Not significant.

The yield potential of 9062680 for biofuel production and the appropriate management regime for this species were also examined from 2000-2002. Plots planted at the Jamie L. Whitten PMC were subjected to two management regimes, a single clip and two clippings per growing season. In 2000, the one clip plots were not harvested until September, but the shoot material began to dry down significantly after August, so the harvest date was moved up in subsequent years to avoid yield losses. Highest yields in each year were from the two-cut system, when the plants were clipped in mid-June and mid-September (Table 6). Scott Edwards presented further information on this study at this symposium (Edwards and Douglas, In Press).

Table 6. Season total yield of 9062680 eastern gamagrass harvested for biomass production using two clipping regimes at Coffeeville, Mississippi. (Adapted from Edwards and Douglas In Press.)

Regime	2000†	2001	2002	Avg.
	kg ha^{-1}			
1 Cut	8740b‡	12 799	7780b	9773
2 Cut	14 833a	14 660	12 172a	13 888

† 1-cut treatment approximately one month later than in following years (September vs. August).

‡ Yields in each column followed by different letters are significantly different at $P<0.05$.

Seed Production and Stand Establishment

Problems that have hindered extensive planting of eastern gamagrass are: 1) Inadequate seed production, caused by few fertile tillers produced per plant, low number of female flowers per inflorescence, and indeterminate seed ripening (Jackson, 1990); 2) Poor seed quality, due to difficulty in removing immature, unfilled seed during the seed processing operation (Douglas et al., 2000b); and 3) Poor field establishment, due to dormancy and poor seed quality of some commercial seed lots (Ahring and Frank, 1968).

Tetraploid forms of eastern gamagrass mainly produce seed by apomixis (Jackson et al., 1992), which reduces or eliminates the need for isolating production blocks of 9062680 from other eastern gamagrass populations. The inherent seed production potential of eastern gamagrass cannot be altered significantly; however, yields of each eastern gamagrass selection can be maximized by appropriately timing the harvest. In Coffeeville, the optimum harvest period for this accession is in mid-July. Accession 9062680 has a slight tendency to lodge, but this has not interfered with harvesting operations. A study is currently underway to determine the seed production response of 9062680 to N applications. Plots are planted at the Jamie L. Whitten PMC, the Prairie Research Unit, and at Mississippi State University. Nitrogen rates used are 0, 112 kg/ha in single and split applications and 224 kg/ha in single and split applications. None of the N rates increased seed production when compared to the control (0 kg ha^{-1}) during the first year of the study. Perennial crops may require two to five years before seed production response to N applications is noted (Wheeler and Hill, 1957).

Douglas et al. (2000b) have shown that the seed lot quality problem can be greatly improved by employing special cleaning methods, such as using an air-fractionating aspirator or a gravity table. Although a mixed lot of eastern gamagrass was used in this study, a similar improvement could be obtained for seed lots of 9062680. All lots used had been cleaned as thoroughly as possible with a standard air-screen cleaner, yet the percentage of filled, high quality seed was only 47% for one lot and 23% for the other two lots (Table 7). If these lots had not received further cleaning with either the aspirator or gravity table, then a poor field stand would have resulted.

The hard, cupluate fruitcase of eastern gamagrass seeds is the mechanism that imposes dormancy on the embryo contained within (Anderson, 1985). Stratification for 6 to 8 weeks is the standard treatment to overcome this dormancy (Ahring and Frank, 1968); however, stratified seed is somewhat difficult to ship, store, and plant. Hot water treatments, that might potentially substitute for the effect of stratification on the fruitcase, and chemical treatments, such as potassium nitrate, gibberellic acid, and kinetin, that might improve establishment of stratified seeds, were all tested in germinator and field trials at the Jamie L. Whitten PMC (Grabowski and Douglas, 2000). None proved to improve field establishment compared to stratification alone. So, further testing was begun in 2002 to determine the optimum stratification period for seed of 9062680. Seeds exposed to stratification periods ranging from 2 to 10 weeks were planted in the greenhouse. At the same time, extended stratification periods are being tested to determine if increased stratification periods have an adverse or beneficial effect on germination. Stratification periods of 2, 4, 6, 8 10, and 12 months are being tested, with seeds planted in uniform conditions in the germinator. Results of these studies should be available by the time seed producers are ready to market Highlander seed.

Table 7. Percent seed fill of eastern gamagrass seed lots A, B, and C conditioned using an air-fractionating aspirator (AFA) and lot C conditioned using a gravity separator (GS). (Adapted from Douglas et al., 2000b.)

	AFA			GS
	Seed Lot			
Fraction	A	B	C	C
	%			
1	93	90	87	90
2	90	90	80	30
3	57	73	43	--
4	10	20	20	--
Control	47	23	23	23
LSD (0.05)	22	12	25	30

A study conducted at the Jamie L. Whitten PMC examined the effect of planting depth on germination of eastern gamagrass seeds. If stratified seeds could emerge from deeper planting depths where soil moisture is higher then they would be less likely to be exposed to dry conditions that can cause a resumption of dormancy. Stratified seeds of both 9062680 and PMK-24 were planted at depths ranging from 13 to 76 mm in field soil during 1999 and 2000. There was no difference in emergence between the eastern gamagrass types; however, there were differences between planting depths (Table 8). Although seeds were capable of emerging from the deepest planting depth of 76 mm, because they emerged more slowly, establishment would be improved if planted in the field at a shallower depth. Planting at 13 mm would not be recommended, even though emergence in this study was high, because of the increased potential for seeds to reenter dormancy in drier years.

Table 8. Percent emergence at 7, 14, and 21 days after planting in 1999 and at 14 and 21 days after planting in 2000 as a function of planting depth at Coffeeville, Mississippi. (Adapted from Douglas, 2000.)

Days†	Planting Depth (mm)					
	13	25	38	51	64	76
	1999					
	--%--					
7	43a‡	25b	16bc	11bc	6c	5c
14	60a	43ab	39ab	33bc	16c	16c
21	65a	59ab	53ab	50ab	38b	36b
	2000					
14	66a	64a	58ab	40bc	34c	30c
21	76a	74a	64ab	56abc	48bc	41c

† No seeds had emerged by the 7-day evaluation period in 2000.

‡ Percentages followed by different letters in each row are significantly different at $P<0.05$.

The consistent performance of 9062680 during testing appears to provide ample justification for releasing it for commercial production. The results of the seed production and management research will allow seed growers to manage stands for optimum seed production and it is hoped that 'Highlander' will be available on the commercial market in the next three or four years. Then potential landowners in the Southeast can utilize 'Highlander' for forage production and the other uses outlined in this paper, using the management techniques developed by the extensive testing done by the Jamie L. Whitten PMC and cooperating agencies.

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