UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
COFFEEVILLE, MISSISSIPPI

and

MISSISSIPPI AGRICULTURAL AND FORESTRY EXPERIMENT STATION
MISSISSIPPI STATE, MISSISSIPPI

and

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
AMERICUS, GEORGIA

NOTICE OF RELEASE OF 'HIGHLANDER' EASTERN GAMAGRASS

The Natural Resources Conservation Service (NRCS), U.S. Department of Agriculture (USDA) and the Mississippi Agricultural and Forestry Experiment Station announce the naming and release of 'Highlander' eastern gamagrass [*Tripsacum dactyloides* (L.) L.]. Highlander was tested under the accession number 9062680.

Collection Site Information: Highlander was collected in 1990 by Gregg Brann in Montgomery County, Tennessee (MLRA 122). Seeds were collected from plants on the Fort Campbell Army Base along Woodlawn Road at 36°32' latitude and 88°30'longitude. It was growing on a southern exposure on a Dickson silt loam with a 3 % slope. Collection site elevation was 182 meters (600 feet) and average annual precipitation for this location is 1016 millimeters (40 inches).

Description: Eastern gamagrass is a native grass that can be found from Massachusetts, west to Illinois and Nebraska, and south to the West Indies, Central America, and Brazil. Highlander eastern gamagrass forms large clumps, with thick, knotty, rhizomes. Mature foliage height ranges from 0.6 to 2 meters (1.5 to 5 feet) tall. Foliage is a bluish-green color and the blades are usually 1 to 2 centimeters wide and scabrous on the margins. Flowers are produced from June to August, with maximum seed production generally occurring in mid-July. Flowering culms are from 2 to 3.5 meters (5 to 9 feet) tall and may lodge somewhat when seeds mature. Racemes are 15 to 25 centimeters (6 to 10 inches), with the separate staminate flowers held distally. Pistillate spikelets are 7 to 10 millimeters (0.25 to 0.4 inches) long (Hitchcock, 1951). Seeds are produced apomicically. The caryopses are contained in a fruitcase composed of hardened segments of the rachis and lignified outer glumes. Highlander is a tetraploid ($2n = 72$) (Chet Dewald, personal communication).

Potential Uses: Highlander is recommended for forage production. It is best used as a hay crop; however, it can be grazed if given appropriate management (i.e. rotational grazing) to prevent damage to the plant stand. It also has potential as a perennial silage crop and as a source of

biomass for bioenergy production. It can be used in many types of conservation plantings, such as buffers and vegetative barriers.

Method of Breeding and Selection:

Initial evaluation: Highlander was initially evaluated at the USDA-NRCS Jamie L. Whitten Plant Materials Center (PMC), Coffeeville, Mississippi, from 1992 through 1994. A total of 73 accessions, collected from nine states in the Southeast and southern Great Plains of the United States, were included in the study. From these initial evaluations, Highlander was determined to have superior vigor, growth form and development, and disease resistance (Snider, 1995).

Regional Genotype Trial: Highlander was selected by the PMC for inclusion in an regional trial comparing 13 eastern gamagrass accessions from southern and western seed sources (Snider, 1995). This trial was conducted from 1996 through 1998 at nine PMCs, including the Jamie L. Whitten PMC. Yield data was collected at of these six sites (Table 1) (Douglas et al., 2000).

Table 1. Average dry matter (DM yield) from 1996-1998 at six locations. (Adapted from Douglas et al., In Press.)

Accession	Booneville, AR	Knox City, TX	Nacogdoches, TX	Coffeeville, MS	Americus, GA	Brooksville, FL
	----------	----------	----------	kg ha^{-1} ----------	----------	----------
Highlander	14 383	11 155	12 722	18 065	19 133	7522
Jackson	7930	*	14 492	12 427†	19 049	3201
434493	12 830	13 682	8172	14 041†	18 616	12 898
9043629	9032	8120	14 448	12 121†	12 858	7398
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	15 131
9058465	11 436	11 269	11 823	15 653†	16 158	9405
9058495	13 665	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	14 723†	18 810	5942
Mean	11 714	9631	9909	14 606	15 385	8644
LSD (0.05)	2903	3586	7132	------‡	2940	5969

* Indicates that plants died after the first winter.

† Plants were not harvested in 1998 because they succumbed to disease.

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

Accessions 9055975, 9059213, and 9059215 were Florida accessions that did not survive the first winter at Booneville, Arkansas or Coffeeville, Mississippi and 9043762 from the Nacogdoches PMC also did not survive at Coffeeville. Plants of all accessions except Highlander died in the winter of 1997 or the early spring of 1998 at the Coffeeville location due to a disease problem. Plant and soil samples were taken and it was determined that *Pythium* spp. and *Rhizoctonia* spp. were present, but inoculations would be required to confirm whether either or both of the organisms were the cause of the mortality.

Genotype testing in Mississippi: Yields of Highlander, Pete and Jackson eastern gamagrass were compared at Coffeeville, Prairie, and Raymond, Mississippi (Table 2). Dry matter yields of Highlander and Jackson were comparable at all locations except Coffeeville, where Jackson once

again succumbed to same disease discussed previously. Yields of Pete were lower at all locations, however, the difference was only significant in 2001 at the Prairie location.

Additional genotype testing was conducted at Mississippi State, Mississippi, comparing Highlander to other superior accessions from the initial evaluations at the Coffeeville PMC. Dry matter yields from 2000 and 2001 are presented in Table 3 (Lang et al., 2002). Highlander was the highest yielding accession in 2000. Although 9058543 produced significantly higher yields in 2001, Highlander was the most uniform producer during the two years.

Table 2. 2001 and 2002 dry matter yield of Highlander and Jackson eastern gamagrass at Coffeeville, Prairie, and Raymond, Mississippi.

	Coffeeville		Prairie		Raymond	
	2001	2002[†]	2001	2002	2001	2002
	kg ha^{-1}					
Highlander	13 801	8316	16 165	14 371	----[§]	21 600
Pete	10 972	7409	11 581	12 454	----	26 280
Jackson	12 415	----[‡]	18 822	16 199	----	18 130
LSD (0.05)	NS		2971	NS		NS

[†] Two harvests were made this year as opposed to three harvests in 2001.
[‡] No plants survived after 2001. Plants showed signs of *Pythium* spp. and *Rhizoctonia* spp damage.
[§] Not harvested in 2001.

Table 3. 2000 and 2001 dry matter yield of eastern gamagrass accessions at Mississippi State, Mississippi.

Accession	2000	2001
	kg ha^{-1}	
Highlander	13 011	12 073
9058543	8667	14 067
9062708	6351	11 248
9062714	5402	11 219
LSD (0.05)	3786	1672

Forage Production Comparisons of other Warm Season Grasses: Studies were conducted at the PMC from 1996 through 1998 to determine how forage yield and quality of Highlander, 'Tifton 44' bermudagrass , and 'Alamo' switchgrass responded to 30 and 45-day clipping frequencies (Table 4).

Table 4. Average yield of three warm season grasses clipped on 30 and 45-day frequencies from 1996-1998 at Coffeeville, Mississippi. (Adapted from Edwards et al., 2000.)

Species	30-day	45-day	LSD (0.05)
	kg ha^{-1}		
Highlander eastern gamagrass	10 957	13 952	2821
Tifton 44 bermudagrass	12 078	11 155	777
Alamo switchgrass	7454	8722	1046

Table 5. 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 et al., 2000.)

	Highlander 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.

A 45-day clipping frequency typically represents two to three harvests per growing season in the lower southern states, but is greatly influenced by moisture and length of growing season. Highlander clipped at 45 days produced an average dry matter yield of 13 952 kg ha^{-1} over the three years with no significant variation between years. Bermudagrass clipped at 30 days resulted in one more clipping per year but only produced an average DM yield of 12 078 kg ha^{-1}. Clipping on a 30-day frequency reduced stands allowing weeds to invade both Highlander and Alamo. A 45-day clipping frequency is recommended for Highlander for sustainable yields.

Highlander's response to N fertilization was evaluated at three locations, Coffeeville, Prairie and Mississippi State, Mississippi, in 2001 and 2002. (Figures 1-3) (Douglas et al., In Press). Results of these tests indicate that Highlander responds to increasing rates of N on silt loam and clay soils and has the capability to produce substantial amounts of biomass.

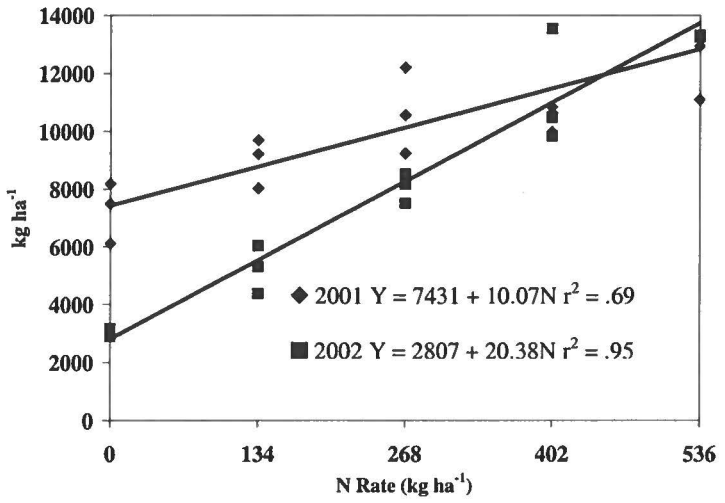

Fig. 1. Season total dry matter yield for Highlander in 2001 and 2002 as a function of N rates at Prairie, Mississippi.

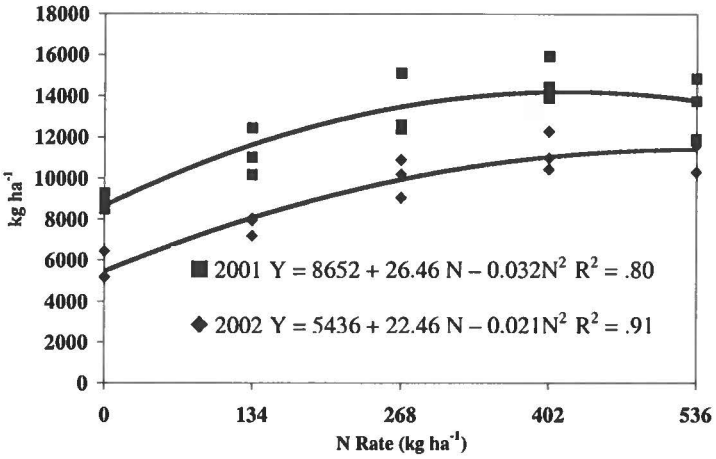

Fig. 2. Season total dry matter yield for Highlander in 2001 and 2002 as a function of N rates at Coffeeville, Mississippi.

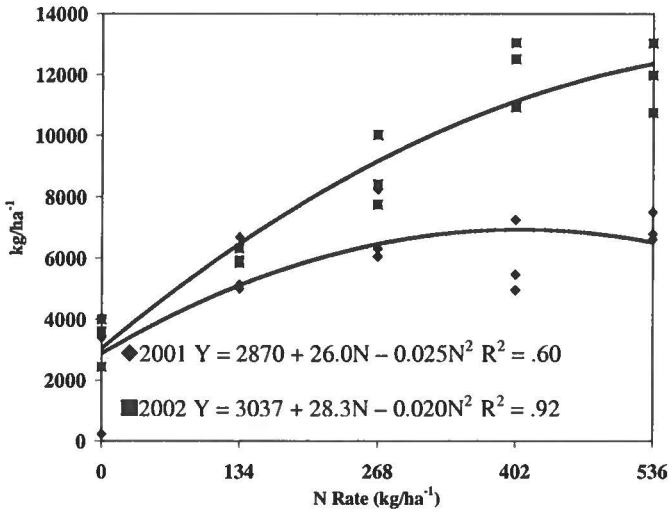

Fig. 3. Season total dry matter yield for Highlander in 2001 and 2002 as a function of N rates at Mississippi State, Mississippi.

Silage Production: A study comparing production and quality of silage from Highlander to silage from hybrid corn was established in 2001 at Newton and Holly Springs, Mississippi. Highlander was harvested two to three times during the growing season, whereas corn yields are from a single harvest (Table 6).

Table 6. 2002 silage yield and quality estimates of Highlander eastern gamagrass and corn varieties at Holly Springs and Newton, Mississippi.

Variety	Yield[†]	CP[‡]	ADF[§]	NDF[¶]	IVTD[#]
	----Mg ha^{-1}----		----------%----------		
			Holly Springs		
Highlander[††]	42.6	10	42	74	54
Pioneer 32K61	35.9	8	32	54	77
			Newton		
Highlander[‡‡]	61.6	10	36	68	64
McNair 508	26.5	9	31	53	80
Northrup King N91-R9	31.4	9	28	64	77

[†] Silage yields based on 35% dry matter; [‡] crude protein; [§] acid detergent fiber; [¶] neutral detergent fiber; [#] *in vitro* true digestibility; [††] forage quality estimates are the average of the 19 June and 5 August harvests; [‡‡] forage quality estimates are from 12 July harvest only (additional harvests 21 May and 2 October).

Total silage yields of Highlander exceeded those of corn at both locations. Forage quality estimates of crude protein, acid detergent fiber, and neutral detergent fiber were similar for Highlander and the corn varieties but digestibility is higher for corn.

Seed Production: Average seed yields of Highlander at Coffeeville range from 105 to 160 kg ha^{-1}. These are similar to those reported for Pete grown in Kansas (USDA-SCS, 1988). Timing of harvest is critical for optimum seed yield, as seed heads are vulnerable to shattering.

Typically, eastern gamagrass plants produce 25 to 30 percent reproductive shoots and 75 to 80 percent vegetative shoots. Counts of reproductive shoots at Coffeeville have shown that Highlander produces 45 to 50 percent more reproductive shoots per plant than Jackson, enabling it to have much higher seed yield potential.

Field Establishment: It is well documented that dormancy in eastern gamagrass seeds adversely affects field establishment. Stratification has been shown to improve germination of eastern gamagrass seeds (Ahring and Frank, 1968) and research by Douglas and Grabowski (2000) confirmed the benefit of stratification on germination of Highlander seed (Table 7).

Table 7. Germination percentage of Highlander eastern gamagrass as influenced by cold, moist stratification for six weeks and no stratification at 7, 14, 21, and 28 days after planting in a growth chamber.

Seed Treatment	Days in Germinator			
	7	14	21	28
	----------%----------			
Stratification	11a[†]	48a	52a	52a
No stratification (control)	0b	1b	3b	3b

[†] Means in columns under days in germination chamber followed by different letters are significantly different at $P<0.05$.

Indeterminate seed maturity is another factor that may indirectly influence field establishment of eastern gamagrass. A typical combine-run harvest consists of complete seed units (cupulate fruitcase with filled seed), incomplete seed units (cupulate fruitcase with unfilled seed) and other non-viable inert matter. Inability to adequately separate filled seeds from unfilled seeds may

lead to poor seed lot quality and therefore poor establishment (Ahring and Franks, 1968). Douglas et al. (2000) found that by utilizing a gravity separator or an air fractionating aspirator it was possible to significantly increase quality of a seed lot cleaned with an conventional air screen cleaner; therefore, improving field establishment potential.

Ecological Considerations and Evaluation: An Environmental Evaluation of Plant Materials Releases was completed using guidelines established by NRCS (USDA-NRCS, 2000), and the best available information for this species. Results of this evaluation determined that Highlander was suitable for release based on the criterion contained in this document. This conclusion is mainly due to the fact that eastern gamagrass is a naturally occurring species in the southeastern United States and planting Highlander would therefore not constitute an introduction of a foreign species into local ecosystems. Any negative impacts on other native plant species would likely be minimal to non-existent. Also, in addition to the substantial evidence that Highlander provides excellent forage for livestock, it also provides critical wildlife habitat and harbors beneficial insects and butterflies.

Conservation Use: Highlander can be used for forage and biofuel production, erosion control, wildlife habitat, and water quality improvement. It has a high degree of tolerance to environmental stresses and will tolerate wet, heavy soils. The apparent resistance to the disease problem encountered at the PMC also corroborates the need to release this plant.

Area of Adaptation: Highlander is well adapted for use in the eastern portions of USDA Hardiness Zones 6b to 8a, using Interstate 35 as its western limit. Current testing has not completely substantiated Zone 6b as the northern limit of its range of adaptation, so it may be adapted in more northern zones.

Availability of Plant Materials: Breeder seed will be maintained by the USDA-NRCS Jamie L. Whitten Plant Materials Center.

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