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FINAL STUDY REPORT
East Texas Plant Materials Center
Nacogdoches, Texas

Evaluation of Native Warm Season Grass for Adaptation to East Texas

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ABSTRACT

Plant adaptation plays a critical role in the success of conservation plantings. Commercially produced native plant species used in conservation plantings have a wide range of origin. The USDA-NRCS ETPMC conducted an adaptation trial of switchgrass (*Panicum virgatum* L.), Indiangrass [*Sorghastrum nutans* (L.) Nash], big bluestem (*Andropogon gerardii* Vitman) and little bluestem [*Schizachyrium scoparium* (Michx.) Nash] cultivars and pre-varietal releases for resource conservation programs in NRCS administrative Zone 4 which is primarily in the Western Coastal Plain's, Major Land Resource Area (MLRA) 133b. Cultivar and pre-varietal germplasm releases from the USDA-NRCS Plant Materials Program were planted in a randomized complete block design at the East Texas Plant Materials Center (ETPMC) and evaluated for yield, stand persistence, plant height, and disease and insect resistance. Switchgrass cultivars performed well with the lowland types producing yields in excess of 15,000 lb/acre at maturity. Stand survival of Indiangrass remained > 80%. Except for 'Earl', big bluestems entries also maintained > 80% stand survival. Little bluestem entries showed a decline in stand except for Coastal Plain Germplasm which increased to 100% from 2013-2018. Results from this study will be used to update the Texas NRCS planting standards for NRCS administrative Zone 4.

INTRODUCTION

Native warm season grasses provide critical habitat for wildlife, forage for livestock, and structure for soil conservation (Grelen and Hughes, 1984; McKenzie, 2002; USDA-NRCS, 1999). The USDA-NRCS Plant Materials Program evaluates and selects native grasses for commercial production through its network of PMCs (Alderson and Sharp, 1999). The key to conservation of natural resources is choosing the best adapted cultivar or pre-varietal release for the intended conservation purpose. There are several cultivars and pre-varietal germplasms commercially available for resource conservation programs, but information on their adaptation is limited in NRCS Zone 4 which encompasses MLRA 133B in East Texas. The objective of this study was to evaluate commercially available cultivars and pre-varietal germplasms of little bluestem, switchgrass, big bluestem and Indiangrass for adaptation and productivity for conservation programs in NRCS Zone 4 in eastern Texas (NRCS Zone 4).

MATERIALS AND METHODS

Cultivar and pre-varietal seed were obtained from commercial growers and or the USDA-NRCS Plant Materials Center (Table 1). Seeding rate for big bluestem, Indiangrass, little bluestem and switchgrass was 6, 4.5, 3.4, and 2.8 pure live seed (PLS) lb/acre, respectively.

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Plots were planted at the USDA-NRCS ETPMC on 4 June 2013 with a Hege 1000 plot drill (Hege Equipment Inc. Colwich, KS) in a randomized complete block with 4 replications on a Woden fine sandy loam soil. Plot size was 6.6 -ft x 24-ft with a 3-foot alley between plots and a 5-foot alley between native grass blocks. Plots were irrigated as needed to accelerate establishment in 2013 only. A broadcast application of 250 lb of 13-13-13 fertilizer was applied on 21 April 2014. No additional fertilizer was applied during the study. Weeds were controlled with spot applications of glyphosate and an application of Prowl H2O at a rate of 4 pints/acre in March of each study year. Weeds within plots were removed by hand.

Table 1. Cultivars and pre-varietal selections of native warm season grasses. East Texas Plant Materials Center, Nacogdoches, TX.

Warm season grass	Originating PMC
Big bluestem	
Earl	James E. "Bud" Smith, Knox City, TX
Kaw	Manhattan PMC, Manhattan, KS
OZ-70 Germplasm	Elsberry PMC, Elsberry, MO
Rountree	Elsberry PMC, Elsberry, MO
Indiangrass	
Americus	Jimmy Carter PMC, Americus, GA
Cheyenne	Manhattan PMC, Manhattan, KS
Lometa	James E. "Bud" Smith, Knox City, TX
Osage	Manhattan PMC, Manhattan, KS
Rumsey	Elsberry PMC, Elsberry, MO
Little Bluestem	
Aldous	Manhattan PMC, Manhattan, KS
Cimarron	Manhattan PMC, Manhattan, KS
Coastal Plains Germplasm	East Texas PMC, Nacogdoches, TX
OK Select	James E. "Bud" Smith PMC, Knox City, TX
Switchgrass	
Alamo	James E. "Bud" Smith PMC, Knox City, TX
Blackwell	Manhattan PMC, Manhattan, KS
Cave-in-Rock	Elsberry PMC, Elsberry, MO
Kanlow	Manhattan PMC, Manhattan, KS

Survival was determined by measuring the percent coverage of the plot. A frequency grid was used to determine percent stand according to procedures described by Vogel and Master (2001). Disease, insect resistance, and over all plant vigor was recorded annually when plants reached inflorescence on a scale of 1-9 where 1 = no damage and 9 = severe damage. These ratings were combined and averaged over the duration of the study to develop an adaptation rating. The adaptation rating was transformed to a 1-10 scale with 10 being best, 5 average and 1 worst, and was used to rank entries for overall adaptation. Yield was determined at the boot stage of growth and at maturity in 2014 and 2016 (Moore et al., 1991). A 3-ft swath was harvested from the center of the plot at a 6-inch height with a forage harvester (RCI, Mayville,

WI). Samples for dry matter determination were dried at 65°C for 24 hours or until a constant sample weight was obtained. Crude protein was estimated by multiplying % N content by 6.25. Plant height was taken at maturity by placing a measuring stick at the soil surface and measuring the absolute plant height at 5 random locations and averaging the recorded heights.

Data was analyzed with the analysis of variance procedure in Statistix 10 (Analytical Software, Tallahassee, FL). Mean separation was performed using Tukey's Honest Significant Difference (HSD) at $P<0.05$.

RESULTS AND DISCUSSION

The study received near normal rainfall in all years except in 2015 and 2017, where rainfall totals were 26 and 10.2 inches, respectively, above the 30-year average (Table 2).

Table 2. Monthly and yearly rainfall in 2013-2018, and 6-year average. ETPMC, Nacogdoches, TX.

Month	2013	2014	2015	2016	2017	2018	30-year Average
	----------inches----------						
January	5.9	1.8	8.0	2.4	5.3	1.2	4.0
February	3.7	2.3	2.9	1.3	2.4	4.4	3.5
March	2.5	3.6	7.4	7.3	2.1	4.8	3.8
April	1.9	1.5	4.0	3.8	4.1	5.1	3.9
May	2.4	7.0	13.1	7.0	6.6	0.9	5.0
June	3.8	2.2	7.8	2.3	5.7	0.8	4.1
July	4.6	4.2	2.2	1.0	7.2	4.3	3.0
August	0.7	1.6	0.8	9.4	11.1	0.4	2.6
September	5.8	4.1	1.7	2.8	1.9	6.8	4.1
October	7.1	5.5	5.2	1.2	4.5	9.2	3.7
November	2.7	5.6	12.2	1.7	2.6	9.5	4.1
December	2.3	2.3	6.8	5.2	2.8	0	4.3
Totals	43.5	41.7	72.1	45.4	56.3	47.4	46.1

Little Bluestem

Little bluestem entries varied in production and were greatly influenced by stage of growth in 2014 and 2016, and 2-year average (Table 3). Coastal Plains Germplasm was significantly taller than other cultivars which contributed to significantly higher yields at either growth stage, excluding boot stage in the establishment year. Crude protein was similar among entries and averaged 7% (data not shown). There was no notable foliar disease or insect damage on any entry except 'Cimarron' (data not shown). Coastal Plains Germplasm had the highest adaptation rate followed by OK Select Germplasm (Table 4). 'Aldous' and 'Cimarron' had the lowest adaptation ratings and were also the least productive entries in the study (Table 3). Grasses are more vigorous when grown close to the center of their area of climatic adaptation

but are more sensitive to climatic changes and use when moved farther away from their origin (Leithead et al., 1971). Percent stand decreased for all entries except Coastal Plains Germplasm, which significantly increased in stand from 48% in 2013 to 100% in 2018 while 'Cimarron' declined by 50% (Table 4). It is important to note that Coastal Plains Germplasm not only increased percent stand within its plots, but also expanded into neighboring plots as they declined (Figure 1).

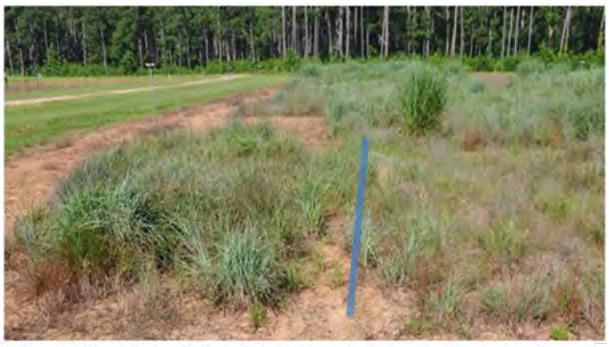

Fig. 1. Coastal Plains Germplasm seen left, expanding across the alley, marked in blue, into a weaker plot of 'Cimarron' seen right.

Big Bluestem

Big bluestem entries showed better adaptation to East Texas than many of the little bluestems. There was no insect or disease damage observed on any of the entries (data not shown). Crude protein was similar among entries and averaged 7% (data not shown). OZ-70 Germplasm was among the highest producing entries at the boot stage and maturity, and produced significantly more biomass at maturity in 2016 (Table 5). OZ-70 Germplasm and 'Rountree' and 'Kaw' had significantly better stand survival compared to 'Earl' (Table 6). 'Kaw' declined to 78% stand but remained in the same mean grouping with 'Rountree' and OZ-70 Germplasm (Table 6). All cultivars achieved 100% stand in 2013, except for 'Earl' which only produced a 28% stand (Table 6). Further investigation of the seed quality of 'Earl' revealed an 85% germination with seeding rates adjusted to PLS basis according to NRCS standards. Seed quality could not account for 'Earl's' stand failure. 'Earl' originated in north Texas (Alderson and Sharp, 1994) in a 35-inch precipitation zone and may not be adapted to higher rainfall (50 inches) in East Texas although big bluestem occurs throughout the southeastern U.S. (Grelen and Hughes, 1984). This cultivar may not have tolerated the moist soils of East Texas as well as other entries. 'Earl' did increase in stand to 50% by 2016 but had an extremely low adaptation rating of 4.5 compared to other entries (Table 6).

Switchgrass

Switchgrass entries showed no differences in yield at boot stage in 2014. However, 'Kanlow' and 'Alamo' produced more than double the biomass by year end in 2014 compared to 'Cave-in Rock' and 'Blackwell' (Table 7). The switchgrass cultivars performed as expected with the lowland ecotypes 'Kanlow' and 'Alamo' producing greater than double the biomass compared to upland ecotypes 'Blackwell' and 'Cave-in-Rock'. This agrees with biomass production work evaluating switchgrass as a sustainable bioenergy crop (Sanderson et.al. 1996). Biomass was not harvested from 'Cave-in-Rock' and 'Blackwell' in 2016. These plots were contaminated with seed from the larger, lowland ecotypes and would not be representative of 'Blackwell' or 'Cave-in-Rock' cultivars (Table 7). There were no obvious foliar disease or insect issues during the study (data not shown). All switchgrass cultivars persisted and had 100% stands throughout the study. As expected, the lowland cultivars of 'Alamo' and 'Kanlow' were taller than the upland cultivars of 'Blackwell' and 'Cave-in-Rock' (Table 8). Variation in height and other morphological characteristic, as well as chromosomal differences, are well documented for distinguishing between the two ecotypes (Sanderson et al., 1996 and 1999; Alderson and Sharp, 1994; Hultquist, 1996). Crude protein ranged from 6.5% to 8%

with ‘Blackwell’ and ‘Cave-in-Rock’ having slightly higher crude protein than ‘Alamo’ and ‘Kanlow’ (Table 8). All entries had adaptation ratings of 10 (Table 8). Although ‘Blackwell’ and ‘Cave-in-Rock’ became contaminated from seed of adjacent plots, they did persist in this study which indicates they would be suitable for conservation plantings in east Texas.

Indiangrass

Indiangrass cultivars did well overall with ‘Lometa’ and ‘Americus’ producing significantly more biomass than the other entries. ‘Cheyenne’, ‘Rumsey’, and ‘Osage’ produced nearly half as much biomass comparatively by study end (Table 9). All entries maintained between 93% and 100% survival excluding ‘Rumsey’ which decreased from 100% to 79% from 2013- 2018 (Table 10). ‘Americus’ and ‘Lometa’ were the tallest cultivars and ranked highest for adaptation (Table 10). ‘Osage’ had 9% crude protein and was significantly higher than other cultivars, but the magnitude of the differences in protein content were small (Table 10). Observational rows of Indiangrass cultivars and pre-varietal germplasms at the ETPMC show a similar trend in persistence and performance with ‘Cheyenne’ and ‘Rumsey’ declining over time (Figure 2). ‘Rumsey’ showed a trend for greater susceptibility to foliar disease than other cultivars in the study and agrees with Thornburg’s (1982) assessment of moving ecotypes into the southern range and its impact on foliar disease susceptibility.

Fig. 2. Observational rows of Indiangrass after 4 years at the ETPMC, L to R ‘Americus’, ‘Cheyenne’, ‘Rumsey’, and Wynia Germplasm’

CONCLUSION

Cultivar selection is important to the longevity of conservation plantings. Non-adaptive selections diminish over time and result in planting failures, less species diversity, allows non-native species to invade, and increases erosion potential. Evaluations of little bluestem cultivars and pre-varietal germplasms showed Coastal Plains Germplasm as the best selection for use in the Western Coastal Plain. OK Select Germplasm maintained 73% stand or greater and is a suitable choice if Coastal Plains Germplasm is not available. ‘Cimarron’ steadily declined and is not recommended for use in the Western Coastal Plain. ‘Aldous’ maintained a 73% stand throughout the study but had the lowest adaptation score. Its use in the Western Coastal Plain should be avoided unless it is the only available option.

OZ-70 Germplasm and ‘Rountree’ big bluestem were the best choices for use in the Western Coastal Plain. ‘Kaw’ showed an acceptable level of performance but had greater stand loss over the study period. ‘Kaw’ would be suitable for use in the absences of ‘Rountree’ or OZ-70 Germplasm or as a secondary cultivar in conjunction with OZ-70 Germplasm and or ‘Rountree’. ‘Earl’ failed to establish complete a stand. It also had very low adaptation score. Additional plantings are needed to further assess its adaptation in the Western Coastal Plain.

All switchgrass cultivars tested showed excellent adaptation and are recommended for use in the Western Coastal Plain. It is important to note that 'Alamo' and 'Kanlow' can grow very large and increase in population in conservation plantings. They can dominate the planting and outcompete other native species creating a monotypic stand of switchgrass over time. The upland types 'Cave-in-Rock' and 'Blackwell' are better choices for wildlife habitat due to their shorter stature. These cultivars are suitable for conservation cover but may decrease if grazed or harvested for forage.

'Americus' and 'Lometa' Indiangrass were top performing cultivars followed by 'Osage'. 'Rumsey' decreased in stand over time and has shown susceptibility to rust pathogens (*Puccinia* spp.) in the Western Coastal Plain and is not recommended. 'Cheyenne' didn't perform quite as well as 'Lometa' and 'Americus', and had excessive stand loss over time in observational rows of Indiangrass at the ETPMC. More work is needed to determine its adaptation in the NRCS Zone 4 Texas. Its use in the Western Coastal Plain should be avoided until further testing can be done.

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Table 3. Yield of little bluestem cultivars and pre-varietal germplasms at the boot stage and at maturity, USDA-NRCS East Texas Plant Materials Center.

	Year					
	2014		2016		Average	
Cultivar/Germplasm	BS[1/]	MAT[2/]	BS	MAT	BS	MAT
	lb/acre					
Coastal Plains Germplasm	1434	6094 a	5693 a[3/]	8367 a	3564 a	7231 a
OK Select Germplasm	1935	3105 b	2077 b	4765 b	2006 b	3935 b
Cimarron	1542	1865 b	1867 b	2179 b	1705 b	2022 c
Aldous	1178	2834 b	2226 b	2137 b	1702 b	2486 bc
Mean	1522	3475	2966	4362	2244	3919

[1/] BS - boot stage; [2/] MAT - maturity; [3/]Means in columns followed by the same letters are not significantly different at $P<0.05$.

Table 4. Percent stand, plant height, and adaptation scores of little bluestem cultivars and pre-varietal germplasms, USDA-NRCS East Texas Plant Materials Center.

	Percent Stand[1/]		Average	Adaptation[2/]
Cultivar/Germplasm	2013	2018	Height (inches)	2018
Coastal Plains Germplasm	48 b[3/]	100 a	57 a	9
Ok Select Germplasm	93 a	73 b	53 b	7
Cimarron	96 a	48 c	42 b	5
Aldous	88 a	73 b	47 ab	4

[1/]Change in percent cover over time measured with a frequency grid; [2/]Average of all rating scores 10 = best 1 = worst; [3/]Means in columns followed by the same letters are not significantly different at $P<0.05$.

Table 5. Yield of big bluestem cultivars and pre-varietal germplasms at the boot stage and at maturity, USDA-NRCS East Texas Plant Materials Center.

	Year					
	2014		2016		Average	
Cultivar/Germplasm	BS[1/]	MAT[2/]	BS	MAT	BS	MAT
	lb/acre					
Earl	1441	4211	5892	4949 b[3/]	3667	4095 bc
Kaw	1886	3785	7703	9432 a	4795	7107 a
OZ-70	1791	4937	8452	5952 b	5122	5825 ab
Rountree	1355	3139	6432	4043 b	3894	3051 c
Mean	1618	4018	7120	6094	4370	5020

[1/] BS - boot stage; [2/] MAT - maturity; [3/]Means in columns followed by the same letters are not significantly different at $P<0.05$.

Table 6. Percent stand, plant height, and adaptation score of big bluestem cultivars and pre-varietal germplasms, USDA-NRCS East Texas Plant Materials Center.

	Percent Stand[1/]		Average	Adaptation[2/]
Cultivar/Germplasm	2013	2018	Height (inches)	2018
Kaw	100 a	78 ab	59 b	8
Earl	27 b	52 b	56 b	4.5
Rountree	100 a	95 a	55 b	7
OZ-70 Germplasm	100 a	100 a	68 a	10

[1/]Change in percent cover over time measured with a frequency grid; [2/]Average of all rating score 10 = best 1 = worst; [3/]Means in columns followed by the same letters are not significantly different at $P<0.05$.

Table 7. Yield of switchgrass cultivars and pre-varietal germplasms at the boot stage and at maturity, USDA-NRCS East Texas Plant Materials Center.

	Year					
	2014		2016		Average	
Cultivar/Germplasm	BS[1/]	MAT[2/]	BS	MAT	BS	MAT
	lb/acre					
Alamo	1226	16,778 a[3/]	12,330 a	27,294 a	6778	22,036 a
Kanlow	1123	20,171 a	11,192 ab	19,574 ab	6158	19,873 a
Cave-in-Rock	1249	8040 b	NH[4/]	NH	----	----
Blackwell	1225	8255 b	NH	NH	----	----
Mean	1206	13,311	11,761	23,434	6468	20,955

[1/] BS - boot stage; [2/] MAT - maturity; [3/]Means in columns followed by the same letters are not significantly different at $P<0.05$. [4/]NH - not harvested due to contamination from other switchgrass cultivars.

Table 8. Percent stand, plant height, and adaptation score of switchgrass cultivars and pre-varietal germplasms, USDA-NRCS East Texas Plant Materials Center.

	Percent Stand[1/]		Average	Adaptation[2/]	Crude Protein
Cultivar/Germplasm	2013	2018	Height (inches)	2018	Boot Stage
Alamo	100	100	86 a	10	6.5 c
Blackwell	100	100	66 b	10	7.1 b
Cave-in-Rock	100	100	74 ab	10	8.1 a
Kanlow	100	100	86 a	10	6.8 bc

[1/]Change in percent cover over time measured with a frequency grid; [2/]Average of all rating score 10 = best 1 = worst; [3/]Means in columns followed by the same letters are not significantly different at $P<0.05$.

Table 9. Yield of Indiangrass cultivars and pre-varietal germplasms at the boot stage and at maturity, USDA-NRCS East Texas Plant Materials Center.

	Year					
	2014		2016		Average	
Cultivar/Germplasm	BS[1/]	MAT[2/]	BS	MAT	BS	MAT
	lb/acre					
Lometa	2227	5550 ab	9017 a[3/]	10,932 a	5622 ab	8241 a
Americus	3305	7483 a	8573 ab	8961 a	6618 a	8222 a
Cheyenne	2947	4523 bc	3101 c	5166 b	3025 b	4845 b
Rumsey	3342	3999 bc	4082 bc	5320 b	3712 b	4660 b
Osage	2416	2257 c	5311 abc	5654 b	3864 ab	3956 b
Mean	2847	4762	6017	7207	4432	5985

[1/] BS - boot stage; [2/] MAT - maturity; [3/]Means in columns followed by the same letters are not significantly different at $P<0.05$.

Table 10. Percent stand, plant height, and adaptation score of Indiangrass cultivars and pre-varietal germplasms, USDA-NRCS East Texas Plant Materials Center.

	Percent Stand[1/]		Average	Adaptation[2/]	Crude Protein
Cultivar/Germplasm	2013	2018	Height (inches)	2018	Boot stage
Americus	100	98 a	58 a	10	7 b
Cheyenne	100	99 a	52 b	7	8 b
Lometa	98	93 a	54 ab	9	7 b
Osage	100	100 a	50 b	8	9 a
Rumsey	100	79 b	52 b	8	8 b

[1/]Change in percent cover over time measured with a frequency grid; [2/]Average of all rating score 10 = best 1 = worst; [3/]Means in columns followed by the same letters are not significantly different at $P<0.05$.