TECHNICAL NOTES

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PLANT MATERIALS TECHNICAL NOTE NO. 72

'Windbreaker' Big Sacaton (*Sporobolus wrightii*) A Bio-Energy Forage Source

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The U.S. Department of Agriculture (USDA) developed a comprehensive strategy to meet the goals of the U.S. Renewable Fuels Standards (RFS2) as set out in the Energy Independence and Security Act of 2007 (EISA). The RFS2 mandate calls for the American Economy to be using 36 billion gallons of renewable transportation fuel per year in its transportation fuel supply by 2022 [1].

The 2008 Farm Bill made energy conservation a priority within the conservation programs administered by the Natural Resources Conservation Service (NRCS). Specifically, the Farm Bill made energy a priority for every USDA Land Manager and Conservationist. Within the NRCS, the Plant Materials Program Strategic Plan identifies energy as a critical concern [2].

The network of 27 Plant Material Centers has been identified as uniquely positioned to address the development of plant materials solutions for bio-energy production to meet the RFS2 standard. As part of this network, the USDA-NRCS Los Lunas Plant Materials Center (LLPMC) in Los Lunas, New Mexico prioritizes energy in its work with native, vegetative species. The forage production of a native species used as an alternative energy source is part of the national effort to provide a means of reducing our national dependence on petroleum-based energy. Traditionally switchgrass has been the species most talked about in the role of a native source for the production of biomass based bio-energy.

Switchgrass (*Panicum virgatum*) is a native, robust, perennial, warm-season bunchgrass. Switchgrass is found in the continental US except for in California and the Pacific Northwest. It averages 3- to 5-feet tall and may spread from short, stout rhizomes. Switchgrass is adapted to most climates of the US when planted on suitable soils. It does poorly on some heavy soils, and it can be found naturally on prairies, open oak and pine woodlands, shores, riverbanks, and high brackish marshes along maritime forest ecotones [3].

Switchgrass, because of its ability to produce moderate-to-high biomass yields even on marginal lands, has been a good choice for use in biomass based bio-energy production testing. These characteristics have led to switchgrass being used in several bio-energy conversion processes, including cellulosic ethanol production, biogas, and direct combustions for thermal energy applications. Although switchgrass is adapted to parts of the Southwest, to produce large biomass yields it still requires a larger amount of precipitation than is typical to the climate of the southwestern US. The need for a native grass to possibly replace switchgrass led the LLPMC to look for alternative species, either previously released plant materials or those currently being evaluated.

[1] A USDA regional roadmap to meeting the bio-fuel goals of the Renewable Fuels Standard by 2022

[2] http://nrcs.usda.gov

[3] http://plants.usda.gov

Big Sacaton Evaluations

The LLPMC was already in the process of evaluating big sacaton (*Sporobolus wrightii*), a native grass whose growth habit and adaptability was perceived as being a good candidate for biomass produced bio-energy[4]. Big sacaton is a native, robust perennial, warm-season bunchgrass (Figure 1) and is found growing throughout the southwestern U.S. It typically occurs on low, alluvial flats and flood plains. Its occurrence in New Mexico is widespread on dry plains and hills, and flowering takes place from June to August. Big sacaton is useful for hay, and it is good forage for grazing when green foliage is young and healthy. Big sacaton can grow in sandy, loamy, and heavy soils, but the soils needs to be well-drained. It also grows well in acid, neutral, basic, and saline soils; however, it cannot grow in dense shade. Big sacaton has the potential to be used in several conservation practices including erosion control, forage for livestock and wildlife, wildlife cover, as a xeric landscape plant and as hay mulch for critical area seeding.

In 1980, seed collections of big sacaton were made in 37 distinct locations in Arizona, New Mexico, and Texas (Table 1). These accessions were planted in 1981 into a non-replicated, initial evaluation planting at the LLPMC. After several annual evaluations for growth and survival, ten superior accessions were identified in 1992. The largest plant from each of the ten accessions was then selected for additional evaluation. The selected plants displayed an average leaf height of 1.28 m and an average plant width of 0.75 m, and they exhibited a 9% increase over the original plants in the initial evaluation planting done in 1981.

Table 1: Collection Site Information for the 10 Selected Accessions of Big Sacaton

Accession Number	County and State	Elevation (Feet)	MLRA	Collector
9022264	Socorro, NM	4,200	42	R. Farmer
9022272	Sierra, NM	4,200	70	J.D. Allen
9022273	Dona Ana, NM	3,830	42	E.H. Fuchs
9022335	Guadalupe, NM	4,630	70	D. Abercrombie
9022339	Lincoln, NM	5,200	70	J. Anderson
PI 434453	Texas			Unknown
9022447	Lincoln, NM	6,000	39	J. Anderson
9022340	Socorro, NM	5,700	70	J. Anderson
9029401	Arizona			Unknown
9022352	De Baca, NM	4,000	70	R. Appel

In 1996, clone transplants were produced from the rootstock of the ten superior selected plants and placed in a replicated, hybrid-cross planting to assess the general combining ability of the parents for hybrids. These plants were evaluated and F1 progeny seedlings were produced from the harvested seed. In 1999, progeny seedlings and clonal transplants of the parent plants were transplanted into a semi-random block of eight (8) replicated rows (Figure 2). Evaluations were completed in 2005 and 2006 on the 1999 progeny and clonal planting for expression of hybrid effect and long-term vigor based on leaf height and plant width. No significant difference was found between parent and half-sib progeny or lineage for all variables tested. No hybrid depression was found in the F1 half-sib plants, which supports the use of these parent plants to produce progeny from their seed.

Off-center field evaluations began in 1999 as windstrip plantings to protect valuable cropland from wind erosion using transplants that were started from the selected seed produced at the LLPMC. During the period of 1999 through 2009, the LLPMC conducted over 13 trials using big sacaton in various wind protection plantings throughout New Mexico and Arizona (Attachment 1). These plantings were done to provide the necessary evaluation of big sacaton for inclusion to the list of species being used for windbreaks in the LLPMC service area. The information gathered during the evaluation period showed that big sacaton could be a significant contributor to erosion prevention when used as a windbreak. These evaluations led to the LLPMC to a varietal release of big sacaton named 'Windbreaker.'

[4] http://bioenergy.ornl.gov/papers/misc/switgrs.html

Figure 1: 'Windbreaker' big sacaton *(Sporobolus wrightti)*

Figure 2: Semi-random replicated block at the LLPMC

Prior to releasing 'Windbreaker' in 2011, the amount of biomass produced from the LLPMC evaluation plantings over the years was perceived as substantial for a native grass. It was this forage production and the national priority for conversion to other forms of energy that encouraged the LLPMC to begin an evaluation project on the potential of big sacaton forage production. In 2010, the LLPMC began a three-year study using the existing seed production fields of 'Windbreaker' to examine the biomass production of this particular variety of big sacaton.

The three-year study (2010, 2011 and 2012) was done to evaluate the forage production of big sacaton for optimum seed production grown under the LLPMC's agronomic conditions. The production fields used for the project study were established in 2009 using transplants grown in the LLPMC greenhouse. A total of 1.25 acres were established in fields 8 and 14 at the LLPMC. The evaluation plantings were installed using three separate spacings: 1-ft., 2-ft. and 3-ft. intervals on 38-inch rows. One planting block consisted of 0.45 acres and the other two blocks were 0.40 acres each. The planting blocks were irrigated, fertilized and kept weed free during the three-year study period (Table 2 and Figures 3-6).

Table 2: Biomass Forage Production Study – Agronomic Treatments (*2010-2012)*

Field	Fertilizer Application	Date	Pesticide Application	Date	Irrigation Application (2010)
***2010* Agronomic Treatments**					
8	40 lbs. Phosphorous 40 lbs. Nitrogen	March 2, 2010 July 2, 2010	Pre-emergent	March 4, 2010	3/5, 5/11, 6/17, 7/15, 8/13, 9/13, 10/28
14	40 lbs. Phosphorous 40 lbs. Nitrogen	March 3, 2010 July 2, 2010	Pre-emergent	March 4, 2010	3/10, 5/10, 6/2, 6/17, 7/15, 8/13, 9/13, 10/12
***2011* Agronomic Treatments**					
8	40 lbs. Phosphorous 40 lbs. Nitrogen	February 15, 2011 May 26, 2011	Pre-emergent 2,4-D	April 1, 2011 April 1, 2011	4/7, 4/29, 5/27, 6/22, 7/21, 8/25
14	40 lbs. Phosphorous 40 lbs. Nitrogen	February15, 2011 May 26, 2011	Pre-emergent 2,4-D	April 1, 2011 April 1, 2011	4/6, 4/29, 5/27, 6/22, 7/21, 8/25
***2012* Agronomic Treatments**					
8	40 lbs. Nitrogen 40 lbs. Phosphorous	May 9, 2012 February 14, 2012	Pre-emergent 2,4-D	March 29, 2012	4/11, 5/18, 6/11, 7/2, 7/31, 10/22
14	40 lbs. Nitrogen	May 9, 2012	Pre-emergent	March 29, 2012	4/11, 5/14, 6/8, 7/9, 8/10, 10/3

Table 2: Biomass Forage Production Study – Agronomic Treatments (*2010-2012*)					
Field	**Fertilizer Application**	**Date**	**Pesticide Application**	**Date**	**Irrigation Application (2010)**
	40 lbs. Phosphorous	February 14, 2012	2,4-D		

.During the 2012 growing season, water flow meters were used to measure the irrigation water applied to the fields (Table 3).

Table 3: Biomass Forage Production Study – Irrigation Water Application (*2012*)				
Field	**Acre**	**Irrigation Water Application Date**	**Irrigation Water Application Gallons**	**Inches Per Acre**
8	**0.85**	April 11, 2012	140,500	5.00
		May 14, 2012	91,400	3.40
		June 8, 2012	72,900	2.70
		July 9, 2012	96,400	3.60
		August 10, 2012	68,200	2.50
		October 3, 2012	97,500	3.60
Total Irrigation Application			**566,900**	**20.80**
Average Irrigation/Application			**94,483**	**3.47**
14	**0.40**	April 11, 2012	74,500	2.74
		May 14, 2012	43,500	1.60
		June 8, 2012	56,000	2.10
		July 9, 2012	41,500	1.50
		August 10, 2012	53,900	2.00
		October 3, 2012	45,300	1.70
Total Irrigation Application			**314,700**	**11.64**
Average Irrigation/Application			**52,450**	**1.94**

A random selection of seven plants per plot was used. To accomplish the clipping, three random plots were selected from each of the three separate spacing intervals for a total of nine plots. The center five plants of each plot were then clipped to a 6-inch height. The forage clippings were weighed for green forage weight, and then oven dried for 48 hours to obtain the dry forage produced (Table 4).

Table 4: Biomass Forage Production Study – Forage Green Weight and Dry Weight *(2010-2012)*						
Month	**Field**	**Plant Spacing**	**Avg. Green weight/plot[5] (lbs.)**	**Avg. Green weight/acre[1] (lbs.)**	**Avg. Dry weight/plot [6] (lbs.)**	**Avg. Dry weight/acre[2] (lbs.)**
***2010* Forage Green Weight and Dry Weight**						
April	8	1 ft.	0.034	85.000	0.006	14.152
	8	2 ft.	0.043	61.429	0.007	10.698
	14	3 ft.	0.008	7.273	0.001	0.741
May	8	1 ft.	0.507	1,267.500	0.195	487.500
	8	2 ft.	0.446	637.143	0.153	218.571
	14	3 ft.	0.020	18.182	0.0004	0.364
June	8	1 ft.	0.865	2,162.500	0.367	917.500

[5] Average clipped weight of three random plots, each containing seven plants and clipping the center five plants.

[6] Forage clippings oven dried for 48 hours to obtain the dry weight.

Table 4: Biomass Forage Production Study – Forage Green Weight and Dry Weight *(2010-2012)*

Month	Field	Plant Spacing	Avg. Green weight/plot[5] (lbs.)	Avg. Green weight/acre[1] (lbs.)	Avg. Dry weight/plot [6] (lbs.)	Avg. Dry weight/acre[2] (lbs.)
	8	2 ft.	2.201	3,144.286	0.860	1,228.571
	14	3 ft.	1.033	939.091	0.347	315.454
July	8	1 ft.	1.291	3,227.500	0.747	1,867.500
	8	2 ft.	4.180	5,971.429	1.740	2,485.714
	14	3 ft.	3.187	2,897.273	1.107	1,006.364
August	8	1 ft.	3.827	9,567.500	1.693	4,232.500
	8	2 ft.	11.587	16,552.857	4.840	6,914.286
	14	3 ft.	12.750	11,590.909	4.693	4,266.364
September	8	1 ft.	5.967	14,917.500	2.787	6,967.500
	8	2 ft.	7.620	10,885.714	3.660	5,228.571
	14	3 ft.	12.760	11,600.00	5.740	5,218.182
Total Yearly Average (lbs.)						
		1 ft.	2.082	5,204.583	0.966	2,414.442
		2 ft.	4.346	6,208.810	1.877	2,476.307
		3 ft.	4.960	4,508.780	1.981	1,801.244
***2011* Forage Green Weight and Dry Weight**						
April	8	1 ft.	0.273	682.500	0.160	400.000
	8	2 ft.	0.347	495.714	0.193	275.714
	14	3 ft.	0.893	811.818	0.400	363.636
May	8	1 ft.	0.747	1,867.500	0.340	850.000
	8	2 ft.	1.367	1,952.857	0.547	781.429
	14	3 ft.	4.667	4,242.727	1.653	1,502.727
June	8	1 ft.	1.987	4,967.500	0.867	2,167.500
	8	2 ft.	4.573	6,532.857	1.847	2,638.571
	14	3 ft.	8.713	7,920.909	3.473	3,157.273
July	8	1 ft.	2.573	6,432.500	1.267	3,167.500
	8	2 ft.	7.120	10,171.429	3.417	4,881.429
	14	3 ft.	22.367	20,333.636	8.667	7,879.091
August	8	1 ft.	3.400	8,500.000	1.768	4,420.000
	8	2 ft.	9.484	13,548.571	4.933	7,047.143
	14	3 ft.	33.800	30,727.273	17.576	15,978.181
Total Yearly Average (lbs.)						
		1 ft.	1.796	4,490.000	0.880	2,201.000
		2 ft.	4.578	6,540.286	2.187	3,124.857
		3 ft.	14.088	12,807.271	6.354	5,776.182
***2012* Forage Green Weight and Dry Weight**						
April	8	1 ft.	0.173	432.500	0.093	233.310

Table 4: Biomass Forage Production Study – Forage Green Weight and Dry Weight *(2010-2012)*

Month	Field	Plant Spacing	Avg. Green weight/plot[5] (lbs.)	Avg. Green weight/acre[1] (lbs.)	Avg. Dry weight/plot [6] (lbs.)	Avg. Dry weight/acre[2] (lbs.)
	8	2 ft.	0.627	895.714	0.273	390.000
	14	3 ft.	0.987	897.273	0.407	370.000
May	8	1 ft.	0.767	1,925.00	0.327	817.50
	8	2 ft.	2.880	4,114.286	1.107	1,581.428
	14	3 ft.	4.267	3,879.090	1.633	1,484.545
June	8	1 ft.	1.299	3,247.500	0.570	1,425.000
	8	2 ft.	7.720	11,028.571	3.397	4,852.857
	14	3 ft.	9.853	8,957.272	4.323	3,930.000
July	8	1 ft.	2.140	5,350.000	0.897	2,242.500
	8	2 ft.	9.413	13,447.143	3.953	5,647.143
	14	3 ft.	16.467	14,970.000	6.917	6,288.181
August	8	1 ft.	3.240	8,100.000	1.750	4,375.000
	8	2 ft.	14.827	21,181.428	8.007	11,438.571
	14	3 ft.	15.800	14,363.636	8.530	7,754.545
Total Yearly Average (lbs.)						
		1 ft.	1.524	3,811.000	0.727	1,818.662
		2 ft.	7.093	10,133.428	3.347	4,782.000
		3 ft.	9.475	8,613.454	4.362	2,765.454

Table 5 shows the average biomass weight is shown for the three year clipping period of the big sacaton.

Table 5: Biomass Forage Production Study – Forage Green Weight and Dry Weight Average Over the Three-Year Period *(2010-2012)*

Month	Field	Plant Spacing	Avg. Green weight/plot[7] (lbs.)	Avg. Green weight/acre[3] (lbs.)	Avg. Dry weight/plot [8] (lbs.)	Avg. Dry weight/acre [4] (lbs.)
April	8	1 ft.	0.160	400.000	0.497	215.821
	8	2 ft.	0.339	484.286	0.158	225.471
	14	3 ft.	0.629	572.121	0.269	244.792
May	8	1 ft.	0.674	1,686.667	0.287	718.333
	8	2 ft.	1.564	2,234.762	0.602	860.476
	14	3 ft.	2.985	2,713.333	1.296	995.879
June	8	1 ft.	1.384	3,459.167	0.601	1,503.333
	8	2 ft.	4.831	6,901.905	2.035	2,906.666
	14	3 ft.	6.533	5,939.091	2.714	2,467.576
July	8	1 ft.	2.001	5,003.333	1.164	2,249.524

[7] Average clipped weight of three random plots, each containing seven plants and clipping the center five plants.

[8] Forage clippings oven dried for 48 hours to obtain the dry weight.

Table 5: Biomass Forage Production Study – Forage Green Weight and Dry Weight Average Over the Three-Year Period *(2010-2012)*

Month	Field	Plant Spacing	Avg. Green weight/plot[7] (lbs.)	Avg. Green weight/acre[3] (lbs.)	Avg. Dry weight/plot [8] (lbs.)	Avg. Dry weight/acre [4] (lbs.)
	8	2 ft.	6.904	9,863.333	3.037	4,338.095
	14	3 ft.	14.007	12,733.636	5.564	5,057.879
August	8	1 ft.	3.489	8,722.500	1.737	4,342.500
	8	2 ft.	11.966	17, 094.285	5.927	8,466.666
	14	3 ft.	20.783	18,893.939	10.266	9,333.030
Total Yearly Average (lbs.) Over A Three-Year Period (2010-2012)						
		1 ft.	1.542	3,854.333	0.857	1,805.902
		2 ft.	5.121	7,315.714	2.352	3,359.390
		3 ft.	8.987	8,170.424	4.022	3,619.831

Table 6 shows the random sampling scheme.

Table 6: Biomass Forage Production Study – Random Sampling Scheme (*2010-2012*)

	April Samples		May Samples		June Samples		July Samples		August Samples		September Samples	
Plant Spacing	Row No.	Plant No.	Row No.	Plant No.	Row No.	Plant No.	Row No.	Plant No.	Row No.	Plant No.	Row No.	Plant No.
***2010* Random Sampling Scheme**												
1-ft.	8	14	10	129	14	112	16	159	9	6	19	227
	16	59	04	155	5	95	5	48	2	49	9	38
	15	159	03	148	11	124	4	55	4	219	16	81
2-ft.	16	125	3	102	8	20	16	100	7	33	6	23
	13	63	15	91	3	71	10	80	3	62	12	134
	2	91	17	11	17	122	8	70	14	32	14	13
3-ft.	9	39	10	46	18	12	29	2	12	42	17	6
	13	16	22	39	23	42	28	7	7	7	2	53
	18	39	17	49	12	8	14	16	3	23	23	28
***2011* Random Sampling Scheme**												
1-ft.	17	71	10	119	7	224	18	16	9	80	19	158
	8	126	4	29	16	74	18	211	14	143	6	107
	12	207	13	229	15	247	19	10	5	35	17	83
2-ft.	17	76	16	130	16	76	2	47	16	101	5	48
	18	128	9	108	5	90	8	14	5	113	17	71
	3	19	8	32	4	64	6	88	7	67	5	32
3-ft.	14	48	12	35	27	34	22	13	26	54	18	29
	22	19	19	28	8	41	17	26	28	48	31	34
	22	44	27	46	22	39	2	17	2	47	17	33
***2012* Random Sampling Scheme**												

Table 6: Biomass Forage Production Study – Random Sampling Scheme (*2010-2012*)

Plant Spacing	April Samples		May Samples		June Samples		July Samples		August Samples		September Samples	
	Row No.	Plant No.	Row No.	Plant No.	Row No.	Plant No.	Row No.	Plant No.	Row No.	Plant No.	Row No.	Plant No.
1-ft.	17	179	4	219	7	227	15	21	12	15	7	206
	2	37	8	122	8	67	11	94	10	88	6	19
	8	13	13	158	14	125	8	22	6	191	9	52
2-ft.	14	28	2	16	5	84	9	129	13	120	9	76
	12	100	2	78	12	113	2	40	8	74	12	46
	8	12	4	118	17	112	10	126	8	66	11	71
3-ft.	17	28	11	5	27	27	11	21	26	17	21	30
	26	37	10	15	27	13	17	10	3	11	9	14
	8	14	18	8	22	24	14	8	25	39	15	36

The forage clipping during the study was planned to be during a six month period from April to September. In 2010 the forage was harvested during this six month period, from April to September. In 2011 and 2012 the forage clipping was completed for only a five month period from April to August of each year. This became necessary, due to the fields being harvested for seed prior to the scheduled September clipping. The process of seed harvesting does remove some the forage from each plant, thereby making it impossible to get a proper forage measurement.

Summary

By comparison, switchgrass was producing over 11 tons of dry forage in forage trial plantings at Auburn University, while in August 2012 big sacaton was producing over 5 tons per acre of dry forage in only one plot of the trial plantings at the LLPMC[9]. The difference in these amounts of forage production should not exclude big sacaton as possible bio-energy product. Big sacaton displays the potential to produce higher amounts of forage as it matures.

The three-year study was only a preliminary look at potential of this species for biomass energy production. The fact that this native species is found in the arid Southwest and that its full potential has not been completely ascertained, should encourage more scrutiny for its use in the biofuel industry. Big sacaton will produce a large amount of forage on a limited input of both nutrients and supplemental water. Big sacaton can be grown on marginal sites and on many soil types and is adapted to the climate found in the Southwest U.S. Further investigation will have to look at the physiological characteristics of the big sacaton species in order to determine its capability for conversion into a biofuel[10] .

[9] *Biomass-Bioenergy Crops in the United States: A Changing Paradigm* (2007). Jane M-F Johnson, Mak D. Coleman, Russ Gesch, Abdullah Jaradat, Rob Mitchell, Don Reicosky, W. W. Wilhelm.

[10] *A Screening for Biofuel Feedstock Quality of Perennial Warm-Season Grasses in Semiarid Subtropical Envronments.* April 2012. L.M. Lauriault, M.A. Marsalis, S.V. Angadi, F. E. Contreras-Govea, D. R. Dreesen, and D. M. VanLeeuveen

Figure 3: Field 14 'Windbreaker' big sacaton 3-foot spacing (July 2010 clipping)

Figure 4: Field 14 'Windbreaker' big sacaton 3-foot spacing (July 2011 clipping)

Figure 5: Field 14 'Windbreaker' big sacaton 3-foot spacing (July 2012 clipping)

Figure 6: Field 14 'Windbreaker' big sacaton 3-foot spacing (July 2012)