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BIOMASS PRODUCTION AND ALLOCATION OF SWITCHGRASS CULTIVARS IN TEXAS

R. L. Reed, M. A. Sanderson, M.A. Hussey, W. R. Ocumpaugh, J. C. Read, C. R. Tischler and B. A. Young

Summary

Field trials in Texas with switchgrass (Panicum virgatum L.) were initiated in 1992 as part of the Biofuels Feedstock Development Program sponsored by the U.S. Department of Energy. Yield potential and morphological composition of eight switchgrass cultivars are being evaluated at six locations. 'Alamo' switchgrass has consistently been among the highest yielding entries at all locations during the first year.

Introduction

In response to growing concerns over consumption of nonrenewable fuel sources, the U.S. Department of Energy, through the Biofuels Feedstock Development Program, has initiated a biomass technology research program. The biofuels program includes investigations into biomass production, conversion into fuel, economics, and environmental impacts. Switchgrass was selected for biomass research because of its high yield potential, adaptation to marginal sites, and tolerance to water and nutrient limitations. It is a warm-season perennial species native to most of North America and is a major component in the tall grass prairies. Our objective was to evaluate eight switchgrass cultivars for their agronomic performance and morphological composition as a biomass crop.

Materials and Methods

Switchgrass cultivar evaluation trials are being conducted at Beeville, College Station, Dallas, Knox City, Stephenville and Temple. Field plots were established in 1992 and primary data collection began in 1993. Eight switchgrass entries are being evaluated at all locations and include both upland and lowland ecotypes. Treatments are a one-cut (September or October harvest) or two-cut (June and September or October harvests) system. The experimental design is a split plot with harvest systems as whole plots and cultivars as subplots (10 x 20 ft) in a randomized, complete block design with two replications.

Keywords: biomass / switchgrass.

Plant measurements include biomass yield, plant morphological composition, disease susceptibility and phenological stage (Sanderson, 1992). Plots at all locations received 60 lb N/acre as a single application in early spring. Plots were clipped to a 6-in. stubble and dried in forced air ovens at 131°F for 48 hr for dry matter determination. Fifty tillers at all locations except Temple (25 tillers) were hand clipped at random from each plot immediately after harvest and separated into leaf blade, leaf sheath, stem, and inflorescence.

Results and Discussion

Results of the cultivar trial indicate that location is a key factor in total biomass produced by switchgrass. Sites differ not only with respect to rainfall (Table 1) and temperature, but also in soil characteristics including water holding capacity, cation exchange capacity, organic matter, and rooting depth. College Station is the only lowland site while the other locations are more typical of upland sites. This paper reports data from only one year of a multi-year study and cultivar performance may vary considerably from year to year.

Biomass yields. Biomass yields in 1993 averaged 6,690 lb/acre across locations and ranged from 4,070 lb/acre at Knox City to 10,730 lb/acre at College Station (Tables 2 and 3). Due to poor stands of some cultivars at Stephenville, all plots were evaluated under the one-cut system. At Knox City there was little regrowth following the first harvest (June) in System 2 and a second harvest was not obtained; therefore plots were evaluated as a one-cut system at two harvest dates. There was no response ($P>0.10$) due to number of harvests at Beeville or College Station. 'Alamo' and 'PMT-785' were among the highest yielding cultivars at Beeville, College Station, Knox City and Stephenville and averaged 9,600 and 9,030 lb/acre across systems, respectively (Table 2). Averaged across cultivars our yields were similar to those reported by Hall et al., (1982) for 'Blackwell' under multiple harvests of 5,590 lb/acre.

There was a harvest system by cultivar interaction ($P< 0.01$) at Dallas and Temple. At Dallas, Cave-in-Rock, Kanlow, PMT-279, and PM-785 yields increased by at least 2-fold when harvested twice (Table 3). Two harvests produced 50% more biomass than did one harvest when averaged across cultivars. However, there was severe damage to switchgrass stands by rodents at Dallas, primarily in the single cut plots. Newly emerged inflorescences were chewed off and there were fewer reproductive tillers in two-cut plots during regrowth and therefore less damage. It is unlikely that stand damage would be as severe in extensive plantings. At Temple, PMT-785 produced more biomass under two harvests, while yields of 'Kanlow' were higher under a single harvest. Dry matter yields of 'Pathfinder' switchgrass cut twice per year increased as first harvest

was delayed by 28 d in late spring in Missouri (Anderson and Matches, 1983). These data indicate that switchgrass response to harvest management differs among cultivars.

Tiller mass. Tiller mass is the primary component of yield. Average mass of individual tillers cut once in autumn ranged from 2.3 g/tiller at Knox City to 5.3 g/tiller at Dallas (Table 4). At Beeville and Stephenville, Alamo was among the cultivars with the largest tillers, while 'Caddo' and 'Cave-in-Rock' had the smallest tillers. When first harvested in summer Alamo, Kanlow, and PMT-785 had the largest and Caddo and Cave-in-Rock the smallest tillers at Beeville. While at Temple, Kanlow had the largest and Caddo the smallest tillers.

Regrowth of plots harvested in summer was limited and only provided sufficient material to obtain tiller mass at College Station and Temple. There were no differences among cultivars at College Station with a tiller average of 1.43 g/tiller (Table 4). Alamo had the largest and Caddo the smallest tillers at Temple.

Leaf blade proportion. When harvested once, there were no differences in leaf blade percentage at College Station or Temple (Table 5). At Beeville, Knox City, and Temple, PMT-785 had more than 30% leaf blade while Kanlow had less than 22%. Twidwell et al. (1988) reported 25% leaf blade for Cave-in-Rock, Pathfinder, and 'Trailblazer' in Indiana when 75% of the inflorescence had emerged, which was similar to the leaf blade percentage determined in this study. However, Griffin and Jung (1983) found 38% leaf blade for Blackwell when harvested at seed set in Pennsylvania. Tillers harvested in summer at College Station, Knox City, and Temple were 44, 39, and 39% leaf blade, respectively (Table 5). At Beeville and Dallas, PMT-785 had the highest percentage of leaf blade, although leaf blade percentage was higher for all cultivars at Dallas.

Regrowth tillers harvested in autumn averaged 35 and 42% leaf blade at College Station and Temple (Table 5). There were no differences between cultivars at College Station, however at Temple Caddo and Cave-in-Rock had 10% more leaf blade than 'PMT-279' and PMT-785.

Conclusions

Limited field evaluations suggest that Alamo is the most stable switchgrass cultivar in terms of biomass yield tested in Texas. Alamo produced over 5 tons/acre of dry matter under high rainfall conditions at Beeville, College Station, and Temple. These preliminary results indicate that harvest management affects production and is probably site and cultivar specific.

Acknowledgements

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Literature Cited

Anderson B. and A.G. Matches. 1983. Forage yield, quality, and persistence of switchgrass and Caucasian bluestem. Agron. J. 75:119-124.

Griffin, J.L., and G.A. Jung. 1983. Leaf and stem forage quality of big bluestem and switchgrass. Agron. J. 75:723-726.

Hall, K.E., J.R. George, and R.R. Riedl. 1982. Herbage dry matter yields of switchgrass, big bluestem, and indiangrass with N fertilization. Agron. J. 74:47-51.

Sanderson, M.A. 1992. Morphological development of switchgrass and kleingrass. Agron. J. 84:415-419.

Twidwell, E.K., K.D. Johnson, J.H. Cherney, and J.J. Volenec. 1988. Forage quality and digestion kinetics of switchgrass herbage and morphological components. Crop Sci. 28:778-782.

Table 1. Monthly precipitation at the cultivar evaluation sites in Texas during 1993.

	Beeville	College Station	Dallas	Knox City	Stephenville	Temple
				in.		
January	1.61	6.00	2.04	0.88	2.19	3.77
February	2.26	1.98	6.58	5.06	4.04	3.08
March	4.98	4.61	1.51	0.38	2.47	4.76
April	2.00	3.86	4.54	1.25	3.96	3.75
May	8.16	7.26	2.58	4.84	1.57	7.04
June	7.84	11.12	4.32	3.29	2.24	4.16
July	0.07	0.00	0.00	1.58	0.00	0.00
August	1.25	0.08	2.85	0.21	1.94	0.01
September	0.92	1.95	4.33	1.73	5.20	4.73
October	2.03	4.96	6.10	1.75	4.58	2.90
November	0.59	3.03	2.28	0.79	1.09	1.52
December	5.78	2.39	2.53	1.25	1.36	1.52
Total	37.49	47.24	39.66	23.01	30.64	37.24
Long-term Average	31	39	34	25	29	35

Table 2. Biomass yield of switchgrass cultivars at Beeville, College Station, Knox City, and Stephenville in 1993. Data are averages of two replications and two harvest systems.

Cultivar	Beeville	College Station	Knox City		Stephenville
			June	October	
			lb DM/acre		
Alamo	11,560	14,660	3,720	6,800	7,950
Caddo	3,110	9,320	2,690	4,040	3,210
Cave-in-Rock	2,400	7,970	2,950	3,580	1,560
Kanlow	7,260	12,370	3,750	5,660	3,610
NC-1	6,910	9,420	5,020	3,010	6,360
NC-2	6,530	10,030	4,150	3,150	5,030
PMT-279	8,320	9,800	2,320	4,730	6,790
PMT-785	10,500	12,270	2,580	5,970	9,080
Mean	7,070	10,730	3,400	4,620	5,450
$LSD_{(0.10)}$[1]	1,130	3,490	NS	NS	2,370

[1] Fisher's least significant difference. NS=Not significant.

Table 3. Biomass yield of switchgrass cultivars under two harvest schemes at Dallas and Temple in 1993.

Cultivar	Dallas		Temple	
	One-cut	Two-cut	One-cut	Two-cut
	lb DM/acre			
Alamo	4,710	6,010	10,370	9,840
Caddo	6,690	5,180	5,220	6,580
Cave-in-Rock	470	4,290	3,190	5,670
Kanlow	3,120	6,220	12,230	7,410
NC-1	2,960	4,190	13,960	11,180
NC-2	3,730	2,920	7,330	12,840
PMT-279	2,600	5,670	9,880	7,450
PMT-785	2,520	6,140	5,210	10,350
Mean	3,350	5,080	8,420	8,920
$LSD_{(0.10)}$[1]	1,370	1,830	3,000	3,610

[1] Fisher's least significant difference.

Table 4. Mean tiller mass of switchgrass cultivars grown at six locations under two harvest schemes in 1993.

Cultivar	Beeville	College Station	Dallas	Knox City	Stephen-ville	Temple
One-cut		----------g/tiller----------				
Alamo	3.18	3.19		2.81	5.07	5.98
Caddo	0.69	1.82	2.22	1.47	2.44	2.26
Cave-in-Rock	0.53	1.97		1.92	1.66	3.52
Kanlow	3.24	3.04		2.35	4.15	4.24
NC-1	3.05	5.89	6.65	2.22	6.04	5.38
NC-2	3.77	3.12	7.12	2.23	5.87	5.58
PMT-279	3.27	3.56		2.64	4.09	5.66
PMT-785	3.91	5.84		2.60	4.37	3.64
Mean	2.71	3.55	5.33	2.28	4.21	4.53
$LSD_{(0.05)}$ [1]	1.70	NS	NS	NS	2.41	NS
Two-cut-Summer						
Alamo	2.31	1.91	2.48	2.45		2.80
Caddo	0.78	1.36	1.67	1.23		1.74
Cave-in-Rock	1.14	1.57	1.89	1.21		2.60
Kanlow	2.80	2.49	2.08	2.00		4.04
NC-1	2.76	2.62	3.09	1.70		3.84
NC-2	2.26	1.59	2.34	2.32		3.94
PMT-279	1.78	1.47	1.80	1.90		2.60
PMT-785	2.62	1.98	1.61	1.55		2.94
Mean	2.06	1.80	2.12	1.80		3.06
$LSD_{(0.05)}$	0.91	NS	NS	NS		0.91
Two-cut-Autumn						
Alamo		1.79				1.97
Caddo		1.01				0.54
Cave-in-Rock		1.30				0.84
Kanlow		1.48				1.55
NC-1		2.13				2.22
NC-2		1.51				1.75
PMT-279		1.17				0.87
PMT-785		1.85				1.43
Mean		1.53				1.40
$LSD_{(0.05)}$		NS				0.77

[1] Fisher's least significant difference. NS=Not significant.

Table 5. Leaf blade proportion (percent of dry matter) of switchgrass cultivars grown at six locations in 1993.

Cultivar	Beeville	College Station	Dallas	Knox City	Stephen-ville	Temple
			%			
One-cut						
Alamo	27	33		23	16	20
Caddo	32	32	30	35	26	27
Cave-in-Rock	27	25		33	38	30
Kanlow	21	32		19	13	26
NC-1	19	29	23	17	15	27
NC-2	20	32	20	21	11	26
PMT-279	26	37		27	19	26
PMT-785	34	34		41	32	24
Mean	26	32	24	27	21	26
$LSD_{(0.05)}$[1]	5	NS	5	6	11	NS
Two-cut-Summer						
Alamo	34	42	45	37		39
Caddo	38	43	42	18		39
Cave-in-Rock	32	43	48	48		41
Kanlow	33	40	44	37		33
NC-1	35	43	40	39		38
NC-2	36	45	44	39		38
PMT-279	40	47	50	44		41
PMT-785	44	50	56	51		39
Mean	37	44	46	39		39
$LSD_{(0.05)}$	5	NS	6	NS		NS
Two-cut-Autumn						
Alamo		30				32
Caddo		34				58
Cave-in-Rock		40				53
Kanlow		36				37
NC-1		30				31
NC-2		35				33
PMT-279		40				46
PMT-785		38				42
Mean		35				42
$LSD_{(0.05)}$		NS				6

[1] Fisher's least significant difference. NS=Not significant.