Evaluation of Perennial Forages for Use as Biofuel Crops in Central and Western North Dakota

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Switchgrass plot following the 2011 harvest at Central Grasslands Research Extension Center, Streeter, ND. Photography by Rick Bohn

Introduction

Using biomass as feedstock in bioenergy production has the potential to replace fossil fuels as well as corn grain that may be better used as human and livestock feed. The northern Great Plains provides a vast number of acres for perennial biomass production, particularly in highly erodible and non-productive areas, which would have a low impact on food production. To achieve the most success in biomass conversion, feedstocks most suited to the region in terms of biomass quantity and quality need to be identified. In 2006 the Central Grasslands REC took the lead on a research trial to evaluate perennial forages for biofuel production. The objectives of this research are to:

1. Determine the biomass yield and select chemical composition of perennial herbaceous crops.
2. Compare annual and biennial harvest of biomass yield and maintenance of the stands.
3. Evaluate carbon sequestration and storage of the various perennial crops.

Study Sites

Six sets of plots were located at five sites across central and western North Dakota. Each set of plots contains ten species/varieties of perennial grasses planted alone and in combination in two harvest treatments (annual and biennial). Planted in 2006, the plots are randomized and have three replications. In 2009 three additional sets of plots were seeded at the USDA-ARS Northern Great Plains Field Laboratory in Mandan and at the Ducks Unlimited Ranch north of Wing. Also in 2009 an additional study (sponsored by Ducks Unlimited) was started to evaluate the effect of a 10-inch vs. 3-inch stubble height on the yield and longevity of the perennial forages. In the plots seeded in 2009 prairie cordgrass was substituted for the Basin and Altai wildrye plots as they had not shown much promise.

Due to the poor stand in 2007, the plots at Hettinger were reseeded in 2008. Although they were harvested the following two years, the decision was made in 2010 to abandon these plots as the stand was still not productive enough to obtain meaningful data.

Annual Biofuel Production

Rainfall across central and western North Dakota was above average in 2011 which had varying effects on production (Tables 1, 2, and 3). The **dryland plots at Williston**, for example, all produced well above 2010 levels and above the five-year average (Table 2). For all other sites, yields were mixed for 2011. At **Minot**, half the plots yielded more than 2010 and half showed lower yields. When compared to the five-year average all the cool season grasses (i.e. wheatgrasses) yielded less and the warm season grasses (i.e. switchgrasses) yielded more (Table 1). Yields for some plots at **Streeter** were down partially due to standing water in one corner of the plot area. Also at Streeter the pure warm season plots were sprayed with glyphosate during the 3rd week of May. This application gave good control of the cool season grasses including smooth brome and quackgrass. This chemical application improved the yield of Sunburst switchgrass and its mixtures but the yield of Trailblazer was down from 2010. At **Carrington** all plots had increased yields from 2010 despite a heavy hail storm in early July. All cool season-only plots yielded higher in 2011 than the five-year average, while all warm season-only yields were lower than the five-year average (Table 1). The **irrigated plots at Williston** again yielded the highest overall in 2011 with the high of 5.62 tons/acre for Sunburst switchgrass. All the warm season grasses yielded more in 2011 than 2010 except Dakota switchgrass. All cool season grasses yielded less in 2011 than 2010 except Basin + Altai wildrye and Haymaker intermediate wheatgrass. In comparison to the five-year average all the wheatgrasses at this site yielded less while the warm season grasses were mixed (Table 2).

Biennial Biofuel Production

The biennial harvested plots (harvested every other year) were sampled in 2011. The hypothesis of this study was that by harvesting the biofuel plots every other year the loss in total yield would be offset by the reduction in harvesting costs. For most of the plots the reduction in yearly yield due to biennial harvesting (averaged over the harvested and unharvested years) ranged between 20 to 50 percent (Tables 1, 2 and 3). The dryland plots at Williston varied the most with Sunburst switchgrass + Altai wildrye plots actually having higher yield on the biennial harvest. At this site, the greatest decrease with the biennial harvest was 35.6% on Haymaker intermediate wheatgrass plots. At Carrington the CRP mix with legumes declined the most with a reduction of 54.9%. At Minot, Streeter, and Williston-irrigated Haymaker intermediate wheatgrass declined the most with reductions of 51.2, 59.6 and 45.6%, respectively.

In 2009 four new studies sites were added: annual/biennial plots sites at the Ducks Unlimited (DU) ranch north of Wing, ND and the Agricultural Research Service, Field Laboratory at Mandan; and a new study evaluating the production of these species and combinations in a stubble height comparison (three vs. ten inches) at Wing and Streeter. In these plots prairie cordgrass was substituted for Mustang + Altai wildrye and Manifest intermediate was planted in place of Haymaker intermediate. The yields in 2011 were considerably better at the DU ranch with the highest yield of 4.54 tons/acre for Alkar tall wheatgrass compared to the high of 2.36 tons/acre for the CRP mix with legumes in 2010 (Table 3). The decline in yield due to biennial harvesting ranged from 12.2% for CRP mix to 63.6% for Sunburst switchgrass. The plots at ARS Mandan were not harvested in 2011 due to a weed problem.

Table 1. Total forage production (tons/acre) on annual and biennial harvest systems at each location 2007-2011. Bolded numbers in each column show the top producing species at each location each year. Numbers in the same column within a location followed by the same letter are not significantly different ($P \leq 0.05$).

										Long Term Average Production (ton/ac) * Indicates a significant difference between harvests		
			Total Annual Harvest (ton/ac)					Total Biennial Harvest (ton/ac)		Annual Harvest	Biennial Harvest	Percent
Location	**Planting**	**Species**	**2007**	**2008**	**2009**	**2010**	**2011**	**2009**	**2011**	**2007-11**	**2008-11**	**Difference**
Carrington	Dryland	Alkar Tall Wheatgrass	4.66 bcde	4.37 abc	3.95 bcd	**4.13** a	4.54	4.04 bc	4.82	4.33 abcd	2.22 ab	48.8*
Carrington	Dryland	CRP Mix (Intermediate & Tall Wheatgrass)	4.16 de	3.75 bcd	3.42 de	3.23 de	**4.70**	3.47 c	3.83	3.85 de	1.82 b	52.7*
Carrington	Dryland	CRP Mix (Wheatgrasses +alfalfa+Sweetclover)	4.93 cde	3.79 cd	3.23 e	3.28 de	4.33	3.18 c	3.88	3.91 cde	1.76 b	54.9*
Carrington	Dryland	Haymaker Intermediate Wheatgrass	4.45 bcd	3.35 bcd	3.22 e	2.96 de	3.53	3.42 c	4.38	3.50 ef	1.95 b	44.3*
Carrington	Dryland	Magnar Basin + Mustang Altai wildrye	3.86 e	3.12 d	3.11 e	2.76 e	3.61	3.08 c	3.84	3.29 f	1.73 b	47.5*
Carrington	Dryland	Sunburst Switchgrass	5.36 abc	**5.13** a	**4.91** a	4.04 ab	4.19	5.36 ab	4.66	**4.73** a	2.51 a	47.0*
Carrington	Dryland	Sunburst Switchgrass + Mustang Altai wildrye	5.18 bc	4.96 ab	4.43 ab	3.42 bcd	4.19	**5.76** a	5.13	4.44 ab	**2.72** a	38.7*
Carrington	Dryland	Sunburst Switchgrass + Sunnyview Big Bluestem	5.48 ab	4.86 ab	4.21 bc	3.95 abc	4.26	5.24 ab	**5.24**	4.55 ab	2.62 a	42.4*
Carrington	Dryland	Sunburst Switchgrass + Tall Wheatgrass	5.29 abc	4.00 abcd	3.99 bcd	3.47 bcd	4.23	4.11 bc	4.84	4.20 bcd	2.24 ab	46.7*
Carrington	Dryland	Trailblazer Switchgrass	**6.21** a	4.57 abc	3.69 cde	3.35 cde	4.28	4.02 bc	4.85	4.42 abc	2.22 ab	49.8*
LSD 0.05			1.01	1.25	0.67	0.65	**NS**	1.59	**NS**	0.52	0.53	
R^2			0.65	0.55	0.75	0.66		0.59		0.76	0.64	
Minot	Dryland	Alkar Tall Wheatgrass	4.19 a	4.10 a	3.13	3.32	2.57	**5.42**	3.65	3.46	2.27	34.5
Minot	Dryland	CRP Mix (Intermediate & Tall Wheatgrass)	4.47 a	3.58 ab	2.04	2.10	2.49	4.08	2.69	2.94	1.69	42.3*
Minot	Dryland	CRP Mix (Wheatgrasses +alfalfa+Sweetclover)	4.12 a	3.23 ab	2.80	2.88	3.05	4.19	3.22	3.22	1.85	42.4*
Minot	Dryland	Dakota Switchgrass	1.54 b	1.32 c	2.36	4.02	3.46	3.21	4.38	2.54	1.90	25.3*
Minot	Dryland	Haymaker Intermediate Wheatgrass	3.67 a	**4.13** a	2.45	2.73	2.96	3.76	2.46	3.19	1.56	51.2*
Minot	Dryland	Magnar Basin + Mustang Altai wildrye	2.35 b	2.47 bc	2.72	2.77	2.99	4.20	3.85	2.66	2.01	24.2
Minot	Dryland	Sunburst Switchgrass	2.39 b	1.63 c	2.23	3.48	3.11	4.33	**4.48**	2.57	2.20	14.2
Minot	Dryland	Sunburst Switchgrass + Mustang Altai wildrye	2.29 b	3.57 ab	3.09	3.22	3.26	4.38	4.15	3.09	2.13	30.9
Minot	Dryland	Sunburst Switchgrass + Sunnyview Big Bluestem	2.14 b	1.68 c	2.03	3.82	**3.58**	3.59	3.35	2.65	1.73	34.6
Minot	Dryland	Sunburst Switchgrass + Tall Wheatgrass	**4.58** a	4.09 a	**3.25**	3.45	2.67	5.33	3.84	**3.61**	**2.29**	36.4
LSD 0.05			1.17	1.35	NS	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	
R^2			0.79	0.73								
Streeter	Dryland	Alkar Tall Wheatgrass	3.42 a	2.63 ab	2.32	**2.91**	2.38 bc	4.02 ab	3.87 abc	2.73 abc	1.97 ab	27.8*
Streeter	Dryland	CRP Mix (Intermediate & Tall Wheatgrass)	3.38 a	2.67 ab	2.69	2.58	2.80 bc	3.55 bc	2.83 bcde	2.82 ab	1.60 bc	43.4*
Streeter	Dryland	CRP Mix (Wheatgrasses +alfalfa+Sweetclover)	2.56 b	1.65 cd	2.06	2.36	2.57 bc	2.99 bcd	2.68 bcde	2.24 bcd	1.42 cd	36.7*
Streeter	Dryland	Haymaker Intermediate Wheatgrass	2.70 b	2.74 ab	**3.31**	2.82	2.64 bc	2.86 cd	1.72 e	2.84 ab	1.15 de	59.6*
Streeter	Dryland	Magnar Basin + Mustang Altai wildrye	1.67 c	1.51 cd	1.83	2.15	2.24 c	2.51 ed	2.62 cde	1.88 d	1.28 cde	31.8*
Streeter	Dryland	Sunburst Switchgrass	1.88 c	0.74 de	1.98	2.72	**4.34** a	1.63 ef	3.97 ab	2.33 bcd	1.40 cd	40.0
Streeter	Dryland	Sunburst Switchgrass + Mustang Altai wildrye	1.79 c	2.10 bc	2.37	2.18	3.39 ab	2.78 cd	2.76 bcde	2.37 abcd	1.38 cd	41.5
Streeter	Dryland	Sunburst Switchgrass + Sunnyview Big Bluestem	1.59 c	1.98 bc	1.86	2.19	2.83 bc	2.77 cd	3.73 abcd	2.09 cd	1.63 bc	22.2
Streeter	Dryland	Sunburst Switchgrass + Tall Wheatgrass	**3.94** a	**3.09** a	2.53	2.75	2.62 bc	**4.75** a	**4.20** a	**2.99** a	**2.24** a	25.2*
Streeter	Dryland	Trailblazer Switchgrass	1.71 c	0.00 e	1.83	2.70	2.33 bc	1.24 f	2.50 de	1.72 d	0.93 e	45.6*
LSD 0.05			0.67	0.96	**NS**	**NS**	1.13	1.04	1.34	0.65	0.38	
R^2			0.87	0.80			0.54	0.80	0.58	0.63	0.80	

Table 2. Total forage production (tons/acre) on annual and biennial harvest systems at Williston Research Extension Center 2007-2011. Bolded numbers in each column show the top producing species at each location each year. Numbers in the same column within a location followed by the same letter are not significantly different ($P \leq 0.05$).

										Long Term Average Production (ton/ac) * Indicates a significant difference between harvests		
			Total Annual Harvest (ton/ac)					Total Biennial Harvest (ton/ac)		Annual Harvest	Biennial Harvest	Percent
Location	**Planting**	**Species**	**2007**	**2008**	**2009**	**2010**	**2011**	**2009**	**2011**	**2007-11**	**2008-11**	**Difference**
Williston	Dryland	Alkar Tall Wheatgrass	0.96 ab	0.70	1.05 ab	1.08	1.62	1.16	1.93	1.08 bc	0.77 bc	28.7*
Williston	Dryland	CRP Mix (Intermediate & Tall Wheatgrass)	1.04 a	0.72	1.05 ab	1.15	1.72	**1.40**	2.24	1.14 b	0.91 ab	20.0*
Williston	Dryland	CRP Mix (Wheatgrasses +alfalfa+Sweetclover)	0.87 abc	0.62	0.78 c	1.14	1.97	0.95	1.84	1.07 bc	0.70 c	35.2*
Williston	Dryland	Dakota Switchgrass	0.35 bc	0.60	0.84 bc	1.13	1.92	1.16	2.05	0.97 bc	0.80 bc	17.1
Williston	Dryland	Haymaker Intermediate Wheatgrass	**1.23** a	**0.79**	**1.27** a	**1.32**	**2.08**	1.22	2.22	**1.34** a	0.86 ab	35.6*
Williston	Dryland	Magnar Basin + Mustang Altai wildrye	0.27 c	0.61	0.90 bc	1.00	1.69	1.22	2.13	0.90 c	0.84 bc	6.4
Williston	Dryland	Sunburst Switchgrass	0.27 c	0.50	0.93 bc	1.03	1.95	1.35	2.18	0.93 c	0.88 ab	5.4
Williston	Dryland	Sunburst Switchgrass + Mustang Altai wildrye	0.31 bc	0.75	0.85 bc	0.99	1.75	1.31	**2.68**	0.93 c	**1.00** a	-7.3
Williston	Dryland	Sunburst Switchgrass + Sunnyview Big Bluestem	0.35 bc	0.69	1.00 bc	1.07	1.93	1.15	2.34	1.01 bc	0.87 ab	13.4
Williston	Dryland	Sunburst Switchgrass + Tall Wheatgrass	1.06 a	0.68	0.93 bc	1.05	1.58	1.24	1.92	1.06 bc	0.79 bc	25.5*
LSD 0.05			0.67	**NS**	0.26	**NS**	**NS**	NS	**NS**	0.19	0.15	
R^2			0.57		0.54					0.64	0.56	
Williston	Irrigated	Alkar Tall Wheatgrass	4.98 ab	3.16 e	3.84 bcd	3.23 def	3.08 de	5.48 c	3.71 d	3.66 d	2.30 cd	37.2*
Williston	Irrigated	CRP Mix (Intermediate & Tall Wheatgrass)	4.50 bc	3.24 e	2.80 d	3.41 cde	3.21 de	4.18 d	4.09 bcd	3.43 de	2.07 de	39.8*
Williston	Irrigated	CRP Mix (Wheatgrasses +alfalfa+Sweetclover)	3.72 c	2.80 e	3.48 cd	2.75 ef	2.68 e	3.82 d	3.77 cd	3.09 e	1.90 e	38.5*
Williston	Irrigated	Dakota Switchgrass	4.31 bc	4.91 c	4.75 ab	4.25 bc	3.93 cd	5.43 c	5.22 b	4.43 c	2.66 bc	39.9*
Williston	Irrigated	Haymaker Intermediate Wheatgrass	4.20 bc	3.35 e	3.72 bcd	2.51 f	3.08 de	3.93 d	3.40 d	3.37 de	1.83 e	45.6*
Williston	Irrigated	Magnar Basin + Mustang Altai wildrye	4.19 bc	3.06 e	3.31 cd	3.43 cde	3.69 d	6.57 bc	4.58 bcd	3.54 de	2.79 b	21.1*
Williston	Irrigated	Sunburst Switchgrass	5.83 a	**7.28** a	**5.76** a	5.33 a	**5.62** a	6.96 b	6.67 a	**5.96** a	3.41 a	42.9*
Williston	Irrigated	Sunburst Switchgrass + Mustang Altai wildrye	**5.85** a	5.69 b	5.72 a	**5.44** a	5.59 a	7.09 ab	**7.20** a	5.66 ab	3.57 a	36.9*
Williston	Irrigated	Sunburst Switchgrass + Sunnyview Big Bluestem	4.92 ab	5.87 b	5.02 a	5.11 ab	5.48 ab	**8.23** a	6.80 a	5.28 b	**3.76** a	28.9*
Williston	Irrigated	Sunburst Switchgrass + Tall Wheatgrass	5.61 a	4.27 d	3.92 bc	3.95 cd	4.67 bc	6.12 bc	4.94 bc	4.48 c	2.76 b	38.3*
LSD 0.05			1.03	0.59	1.04	0.87	0.92	1.62	1.20	0.46	0.39	
R^2			0.68	0.96	0.79	0.85	0.86	0.86	0.84	0.95	0.92	

Table 3. Total forage production (tons/acre) on annual and biennial harvest systems at the Ducks Unlimited (DU) site at Wing, ND 2010-2011. Bolded numbers in each column show the top producing species at each location each year. Numbers in the same column within a location followed by the same letter are not significantly different ($P \leq 0.05$).

						Long Term Average Production (ton/ac)		
						* Indicates a significant difference between harvests		
			Total Annual Harvest (ton/ac)		Total Biennial Harvest	Annual Harvest	Biennial Harvest	Percent
Location	**Planting**	**Species**	**2010**	**2011**	**2011**	**2010-11**	**2010-11**	**Difference**
DU	Dryland	Alkar Tall Wheatgrass	2.13 ab	**4.54** a	4.13 a	**3.33** a *	2.06 a	38.0*
DU	Dryland	CRP Mix (Intermediate & Tall Wheatgrass)	1.44 bc	3.88 abc	4.67 a	2.66 ab	2.34 a	12.2
DU	Dryland	CRP Mix (Wheatgrasses +alfalfa+Sweetclover)	**2.36** a	3.38 bc	4.65 a	2.87 ab	2.32 a	19.1
DU	Dryland	Manifest Intermediate Wheatgrass	1.24 c	3.03 c	2.52 b	2.13 bc	1.26 b	40.9
DU	Dryland	Prairie Cordgrass	1.08 c	0.83 d	1.00 c	0.96 d *	0.50 c	47.8*
DU	Dryland	Sunburst Switchgrass	1.42 bc	1.72 d	1.14 c	1.57 cd *	0.57 c	63.6*
DU	Dryland	Sunburst Switchgrass + Mustang Altai wildrye	0.85 c	1.14 d	1.24 bc	1.00 d	0.62 bc	37.9
DU	Dryland	Sunburst Switchgrass + Sunnyview Big Bluestem	0.94 c	1.35 d	1.75 bc	1.15 d	0.87 bc	23.7
DU	Dryland	Sunburst Switchgrass + Tall Wheatgrass	2.29 a	4.33 ab	**4.75** a	3.31 a	**2.38** a	28.2
DU	Dryland	Trailblazer Switchgrass	0.94 c	0.97 d	1.22 bc	0.96 d	0.61 bc	36.1
LSD 0.05			0.83	1.08	1.31	0.80	0.65	
R^2			0.66	0.88	0.86	0.87	0.86	

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Stubble Height Yields

The stubble height study plots were seeded in 2009 at the DU and Streeter sites. The 2010 data (Table 4) indicated that wheatgrasses in the DU site established well. However, other species in that site and all species in the Streeter site did not show good establishment. In 2011 all plots showed improved stands especially at Streeter where all plots showed increased yields. The 10-inch stubble height yielded less than the 3-inch height in all cases except for the CRP mix in the DU sites (7.7% gain) and Sunburst switchgrass + prairie cordgrass at the Streeter sites (0.5% gain) (Table 4).

Prairie cordgrass, switchgrass, and Sunnyview big bluestem (warm-season grasses) were not well established in 2011 on the DU site; therefore, all the species showing significant differences in production between stubble heights did not accurately represent the designated species' performance. All the wheatgrasses both alone and in combination with other species had decreased production for the 10-inch stubble height harvest; however, there was no significant difference in production between stubble height harvests.

In Streeter, tall wheatgrass alone or in combination with others lost more than 30% of production in the 10-inch stubble height harvest as did the switchgrass + big bluestem combination. Results at both locations showed contradictory trends.

Some researchers have found that switchgrass harvested lower than 8 to 10 inches decreased stand vigor dramatically over time. We will continue to conduct this study and evaluate this hypothesis that low cutting height will cause a decline in yield over the long term.

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Table 4. Yield in tons/acre for perennial forages harvested at two stubble heights in 2010 and 2011. Bolded numbers in each column show the top producing species at each location each year. Numbers in the same column within a location followed by the same letter are not significantly different ($P \leq 0.05$).
*Indicates a significant difference in production between stubble height harvests in 2011 or between long term stubble height harvests.

Location and Species	Tons/Acre Stubble Height				Percent Difference in Stubble Height Harvests in 2011	Long Term Average Production Tons/acre)		
	Low (3 in)		High (10 in)			Stubble Height		
Ducks Unlimited Site at Wing, ND	**2010**	**2011**	**2010**	**2011**		**Low 2-Yr-Avg 2010-11**	**High 2-Yr-Avg 2010-11**	**Long Term Percent Difference**
Alkar Tall Wheatgrass	**2.97** a	**4.75** a	**2.00** a	**3.78** a	20.4	**3.86** a	**2.89** a	25.1
CRP Mix (Intermediate & Tall Wheatgrass)	2.35 abc	3.64 bc	1.23 ab	3.19 a	12.4	3.00 abc	2.21 ab	26.1
CRP Mix (Wheatgrasses +alfalfa+Sweetclover)	2.41 ab	3.11 c	1.86 a	3.35 a	-7.7	2.76 bc	2.60 a	5.7
Manifest Intermediate Wheatgrass	1.54 bcd	3.14 c	1.20 ab	1.92 b	38.9	2.34 cd	1.56 bc	33.4
Prairie Cordgrass	0.87 d	1.29 d	0.45 b	0.41 c	68.2*	1.08 e	0.43 d	60.0*
Sunburst Switchgrass	1.25 d	1.11 d	0.59 b	1.07 bc	3.6	1.18 e	0.83 cd	29.7
Sunburst Switchgrass + Prairie Cordgrass	1.44 cd	1.15 d	0.54 b	0.44 c	61.7*	1.30 e	0.49 d	62.1*
Sunburst Switchgrass + Sunnyview Big Bluestem	1.09 d	1.44 d	0.70 b	0.45 c	68.8	1.27 e	0.58 d	54.5*
Sunburst Switchgrass + Tall Wheatgrass	2.75 a	4.50 ab	1.68 a	3.04 a	32.4*	3.63 ab	2.36 ab	34.9
Trailblazer Switchgrass	1.23 d	1.82 d	0.66 b	0.89 c	51.1	1.52 de	0.78 cd	49.0*
LSD 0.05	0.94	0.88	0.84	0.97		0.88	0.89	
R^2	0.72	0.91	0.66	0.89		0.68	0.63	
Streeter								
Alkar Tall Wheatgrass	0.96 abc	3.31 ab	0.25	1.66 ab	49.8*	2.14	0.96	55.2
CRP Mix (Intermediate & Tall Wheatgrass)	1.05 abc	2.71 bc	0.33	1.55 b	42.8*	1.88	0.94	50.0
CRP Mix (Wheatgrasses +alfalfa+Sweetclover)	**1.17** a	2.65 bc	0.47	1.52 b	42.6*	1.91	0.99	48.2
Manifest Intermediate Wheatgrass	0.95 abc	2.72 bc	**0.70**	2.40 a	11.8	1.84	**1.55**	15.6
Prairie Cordgrass	0.35 d	1.55 d	0.08	0.70 c	54.8*	0.95	0.39	59.4
Sunburst Switchgrass	0.74 bcd	3.29 ab	0.39	2.43 a	26.1	2.02	1.41	30.0
Sunburst Switchgrass + Prairie Cordgrass	0.64 cd	2.17 cd	0.30	2.18 ab	-0.5	1.40	1.24	11.4
Sunburst Switchgrass + Sunnyview Big Bluestem	0.67 cd	3.10 ab	0.17	2.13 ab	31.3*	1.88	1.15	38.8
Sunburst Switchgrass + Tall Wheatgrass	1.14 ab	**3.70** a	0.42	**2.46** a	33.5*	**2.42**	1.44	40.5
Trailblazer Switchgrass	0.94 abc	2.72 bc	0.29	2.37 a	12.9	1.83	1.33	27.1
LSD 0.05	0.42	0.67	**NS**	0.81		**NS**	**NS**	
R^2	0.6	0.76		0.67				