Establishment, Persistence, Yield and Harvest Regime of Perennial Forage Species for Bioenergy Production Across Central and Western North Dakota

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Switchgrass, a perennial warm-season grass, has been declared a "model" bioenergy crop in the U.S. However, its establishment and persistence remain questionable across central and western North Dakota due to its soil moisture requirements.

Therefore, several cultivars of switchgrass, along with other promising perennial species, as well as some mixtures, were evaluated across central and western North Dakota. The effects of harvest regimes (annual vs. biennial, high-stubble vs. low-stubble) on stand persistence and biomass yield also were investigated from the perspective of conservation and production. The results from this study can be used to develop appropriate bioenergy production systems to match site-specific situations in North Dakota.

Summary

To develop bioenergy production systems appropriate to specific locations, four species were studied at seven sites across central and western North Dakota from 2006 to 2013. These species were switchgrass, prairie cordgrass, intermediate wheatgrass and tall wheatgrass, and several mixtures. They were evaluated with regard to establishment, persistence, biomass yield and harvest regimes.

Annual vs. biennial harvest regimes were evaluated at the Carrington, Hettinger, Minot, Streeter and Williston study sites, which were seeded in 2006. Study sites at Mandan and Wing were added in 2009. Low-stubble vs. high-stubble harvest regimes also were evaluated at Streeter and Wing, which also were seeded in 2009. All plots were dryland, although an irrigated set of plots was added at Williston.

One year after seeding (2007 and 2010), intermediate wheatgrass, tall wheatgrass, a binary mixture of tall wheatgrass and intermediate wheatgrass, and a binary mixture of tall wheatgrass with 'Sunburst' switchgrass (dominated by tall wheatgrass) established soundly at all seven sites. 'Sunburst' switchgrass and its binary mixture with big bluestem established well at Carrington and Williston (irrigated land) and failed at Hettinger and Williston (dryland). Meanwhile, their successful establishment took two to three years after seeding at Mandan, Minot, Streeter and Wing.

Comparing the seven-year average of production by species within each site, and with annual harvest, 'Sunburst' switchgrass produced the highest biomass at Carrington (4.36 tons/acre), Streeter (2.95 tons/acre) and Williston (irrigated land, 5.74 tons/acre), while intermediate wheatgrass was the highest at Hettinger (2.23 tons/acre) and Williston (dryland, 1.36 tons/acre). The mixture of tall wheatgrass with 'Sunburst' switchgrass had the highest yield at Minot (3.31 tons/acre) during the seven years, with an annual harvest.

Biennial harvest at Carrington and Williston (irrigated land only) accounted for approximately 50 percent of those two annual harvest totals. The high-stubble harvest produced approximately 70 percent of the biomass of the low-stubble harvest for the most promising species or mixtures.

Introduction

The northern Great Plains has been identified as an important area for biomass production. In particular, North Dakota is ranked first in the nation for its potential to produce perennial grasses and other dedicated bioenergy crops (Milbrandt, 2005). After evaluating 34 annual and perennial species in multistate field trials, switchgrass (*Panicum virgatum* L.) was declared a "model" crop for bioenergy production in the U.S.

Switchgrass is native to the tall-grass prairie of North America. However, the northern Great Plains region is a mixed ecoregion with tall-grass prairie on the east and midgrass prairie on the west. In North Dakota, the transition zone occurs at approximately 98°W longitude. Therefore, switchgrass performance remains questionable in this area from an ecological standpoint.

Other promising perennial forage species should be tested in the field if switchgrass cannot perform well in western North Dakota. Furthermore, switchgrass cultivars of southern origin such as 'Alamo,' 'Kanlow,' 'Cave-in-Rock' and 'Blackwell' have uncertain winter hardiness 300 miles north of their origin.

If switchgrass can be established in western North Dakota, further evaluation and selection of adapted cultivars of switchgrass is important.

Producing perennial biomass for bioenergy can help mitigate the negative impacts of fossil fuel on our economy and energy security, as well as provide environmental benefits such as improving soil health, water quality and wildlife habitat. However, these benefits can be realized only with appropriate agronomic practices, in particular, using selected harvest frequencies and stubble heights.

Therefore, the objectives of this study were to compare the performance of two different cultivars of switchgrass and species of intermediate wheatgrass, tall wheatgrass and prairie cordgrass monocultures, as well as mixtures of 1) intermediate wheatgrass and tall wheatgrass, 2) intermediate wheatgrass, tall wheatgrass, alfalfa and yellow sweetclover, 3) switchgrass and tall wheatgrass, 4) switchgrass and Altai wildrye, 5) switchgrass and big bluestem, 6) Altai wildrye and basin wildrye and 7) switchgrass and prairie cordgrass across central and western North Dakota.

Several questions were asked: 1) Could switchgrass establish and persist in central and western North Dakota west of the 980 W longitude? 2) If so, which cultivar would be most productive? 3) If not, what is the alternative to switchgrass? 4) Are monocultures and mixtures similar in production or which is superior? 5) What is the best species or mixtures in each site for biomass production? 6) Do harvest regimes affect the performance of the selected monocultures and mixtures?

Procedures

Field study was conducted at the North Dakota State University Research Extension Centers at Carrington, Hettinger, Minot, Streeter and Williston during 2006 to 2013. The growing-season 30-year average precipitation is: Carrington, 15.2 inches; Streeter, 13.7 inches; Minot, 13.1 inches; Hettinger, 12.1 inches; and Williston, 11.6 inches. At Williston, a side-by-side site comparison of irrigation effect was conducted and included dryland and irrigated sites. Irrigated plots received approximately 6 to 10 inches of water every year as necessary.

The 10 experimental entries of monocultures and mixtures are shown in Table 1. Each field plot measured 30 feet long and 15 feet wide and contained 30 rows spaced 6 inches apart. In 2006, all plots across all sites were seeded the week of May 15, starting in Hettinger (the western-most site) and ending with Carrington (in the east), following seedbed preparation with disking and harrowing. The seeding rate for each experimental entry is shown in Table 1.

The field plots at each site were maintained by different mowing agendas, and herbicides were used for weed control if necessary. The plots were not harvested in 2006 but were mowed at the end of the growing season. Since 2007, plots were harvested every year in the second or third week of September, depending on the weather. A 4-foot-wide strip in the center of each plot was cut to a 3-inch stubble height and weighed.

Dry-matter content of biomass from each plot was measured from a 1- to 2-pound grab sample that was dried at 150 degrees Fahrenheit and used to adjust plot yields to a dry-matter basis. Beginning in 2007, nitrogen (N) fertilizer (56 pounds N/acre) was applied in May to all plots except those containing legumes. The biennial harvests were conducted in 2007, 2009, 2011 and 2013.

Two sites, one at the USDA-ARS station at Mandan and the other on the Ducks Unlimited Coteau farm near Wing, were added to the existing trial in 2009. Agronomic practices such as seedbed preparation, seeding, fertilization, weed control and harvest at these two sites were the same as the others except that in the list of experimental entries, wildryes were replaced by prairie cordgrass due to their poor performance at the other sites in 2007 and 2008.

Also in 2009, two more sets of plots at Wing and Streeter were added to the existing trial to evaluate the effect of harvest stubble height on species performance. Two stubble heights were included: 3-inch and 10-inch. The corresponding agronomic practices were the same as in the existing trial.

Results

Establishment and Persistence. In general, establishment was successful for the cool-season grasses, intermediate wheatgrass and tall wheatgrass in monoculture, as well as their mixture with others, seeded in 2006 at Carrington (Table 2), Hettinger (Table 3), Minot (Table 4), Streeter (Table 5) and Williston (Tables 6 and 7). The same was true for plots seeded in 2009 at Mandan (Table 8), Streeter (Table 10) and Wing (Tables 9 and 11).

However, the persistence of tall wheatgrass seeded in 2006 showed a sharp decrease in 2013 at Carrington (Table 2), in 2012 at Minot (Table 4), in 2011 at Streeter (Table 5) and in 2012 at Williston irrigated land (Table 7). Tall wheatgrass persistence fluctuated through the years at Williston dryland (Table 6) seeded in 2006. More time is needed to detect the same trend for tall wheatgrass persistence at Mandan, Streeter and Wing seeded in 2009.

On the other hand, the establishment of warm-season grasses, switchgrass and big bluestem was complex and varied from site to site. At Carrington and Williston irrigated land, they established well in the first year after seeding in 2006 (Tables 2 and 7). However, their establishment at Minot and Streeter took one and two years after seeding in 2006, respectively

Table 1. Experimental entries of species monocultures and mixtures and the corresponding seeding rate for evaluating biomass yield for bioenergy across central and western North Dakota seeded in May 2006 and 2009.

Species or Mixtures	Abbreviation	Species Traits[1]	Seeding Rate[2]
'Sunburst' switchgrass	Sunburst	C_4 Grass	10
'Trailblazer' switchgrass[3]	Trailblazer	C_4 Grass	10
'Dacotah' switchgrass[3]	Dacotah	C_4 Grass	10
'Alkar' tall wheatgrass	Alkar	C_3 Grass	11
'Haymaker' intermediate wheatgrass[4]	Haymaker	C_3 Grass	10
'Manifest' intermediate wheatgrass[4]	Manifest	C_3 Grass	10
'SD Native' prairie cordgrass[5]	SD Native	C_4 Grass	2
CRP mix 1			
'Haymaker' intermediate wheatgrass[4]	CRP1	C_3 Grass	5
'Manifest' intermediate wheatgrass[4]		C_3 Grass	5
'Alkar' tall wheatgrass		C_3 Grass	6
CRP mix 2			
'Haymaker' intermediate wheatgrass[4]	CRP2	C_3 Grass	4
'Manifest' intermediate wheatgrass[4]		C_3 Grass	4
'Alkar' tall wheatgrass		C_3 Grass	4.5
'Vernal' alfalfa		Legume	1
'Blossom' yellow sweetclover		Legume	0.5
$C_4 + C_3$ 1[1]			
'Sunburst' switchgrass	$C_4C_3$1	C_4 Grass	5
'Alkar' tall wheatgrass		C_3 Grass	5
$C_4 + C_3$ 2			
'Sunburst' switchgrass	$C_4C_3$2	C_4 Grass	7
'Mustang' Altai wildrye		C_3 Grass	11
$C_4 + C_4$ 1			
'Sunburst' switchgrass	$C_4C_4$1	C_4 Grass	7
'Sunnyview' big bluestem		C_4 Grass	2.5
$C_4 + C_4$ 2			
'Sunburst' switchgrass	$C_4C_4$2	C_4 Grass	7
'SD Native' prairie cordgrass		C_4 Grass	1
C_3 combination			
'Mustang' Altai wildrye	C_3C_3	C_3 Grass	11
'Magnar' basin wildrye		C_3 Grass	5

[1] C_4: warm-season species; C_3: cool-season species.
[2] Pounds pure live seed/acre.
[3] 'Trailblazer' switchgrass was seeded at Hettinger, Streeter, and Carrington, while 'Dacotah' switchgrass was seeded at Williston and Minot.
[4] 'Haymaker' intermediate wheatgrass was seeded in 2006, while 'Manifest' intermediate wheatgrass was seeded in 2009.
[5] Prairie cordgrass was seeded in 2009 at Mandan, Streeter and Wing instead of wildryes.

(Tables 4 and 5). Their establishment at Hettinger and Williston dryland failed (Tables 3 and 6). Furthermore, the persistence of well-established switchgrass decreased through the years and plots were invaded by cool-season grasses: smooth brome, quackgrass and/or crested wheatgrass.

Switchgrass did not establish well until three, three and two years after seeding in 2009 at Mandan, Wing and Streeter, respectively (Tables 8 – 11). At Williston irrigated land seeded in 2006, all the plots containing wheatgrasses were invaded by Canada thistle and smooth brome; therefore, wheatgrass persistence decreased through the years.

In general, harvest regimes (annual vs. biennial, low-stubble vs. high-stubble) did not have a significant effect on stand establishment or persistence.

Biomass Yield. The highest yielding monocultures or mixtures varied from site to site, year to year and also with harvest regimes (Tables 12 – 21). For the annual harvest regime seeded in 2006, 'Sunburst' switchgrass produced the highest biomass consistently from 2007 to 2013 at Carrington and Williston irrigated land, with average yields of 4.36 tons/acre and 5.74 tons/acre, respectively (Tables 12 and 17).

At Williston dryland and Hettinger, intermediate wheatgrass was consistently the highest from 2007 to 2013, with an average yield of 1.36 and 2.23 tons/acre, respectively (Tables 13 and 16). At Minot, tall wheatgrass and its mixtures had the highest yield in 2007, 2008 and 2012.

From 2009 to 2011, all the entries were similar, while switchgrass mixed with big bluestem produced the highest amount of biomass in 2013 (Table 14). As a result, the seven-year average was highest for tall wheatgrass and its mixtures (3.31 tons/acre). Results from the Streeter site showed a similar trend as from the Minot site: From 2007 to 2008, the cool-season grasses produced higher biomass than warm-season grasses.

All entries were similar in 2009 and 2010, while from 2011 to 2013, 'Sunburst' switchgrass produced the highest biomass. The seven-year average yield of 'Sunburst' switchgrass was the highest at 2.95 tons/acre.

For the biennial harvest regime seeded in 2006, 'Sunburst' switchgrass mixed with 'Mustang' wildrye produced the highest biomass at Carrington (Table 12), Minot (Table 14) and Williston (Tables 16 and 17), while 'Sunburst' switchgrass alone produced the highest at Streeter (Table 15). By comparison, the biennial harvest in a specific year accounted for 45 to 67 percent, 43 to 112 percent, 32 to 87 percent, 50 to 98 percent and 40 to 103 percent of the two annual harvest combined totals at Carrington, Minot, Streeter, Williston dryland and Williston irrigated land, respectively (Tables 12, 14 – 17).

For the annual harvest regime seeded in 2009, intermediate wheatgrass consistently produced the highest biomass at Mandan and averaged 3.13 tons/acre (Table 18). Tall wheatgrass produced the highest biomass at Wing and averaged 3.77 tons/acre (Table 19). For the biennial harvest regime seeded in 2009, tall wheatgrass mixed with switchgrass produced 5.05 tons/acre at Mandan, which is 90 percent of the yield of the two annual harvest combined totals (Table 18). As for the Wing site, the two wheatgrass mixtures produced 5.36 tons/acre under the biennial harvest, or 84 percent of the yield of the two annual harvest combined totals (Table 19).

Switchgrass mixed with big bluestem produced 2.80 tons/acre on average under the low-stubble harvest regime, while 'Trailblazer' switchgrass produced 2.11 tons/acre on average under the high-stubble harvest regime at Streeter seeded in 2009 (Table 20). However, tall wheatgrass produced the highest at both harvest heights at Wing (Table 21). In general, the biomass yield of high-stubble harvested warm-season grass increased in comparison with low-stubble harvest during the study years at both sites (Table 20 and 21).

Discussion

Several factors can contribute to stand failure in establishing perennial grasses; for example, moisture stress (Sanderson et al., 1999), improper seeding strategies (McGinnies, 1960), poor seed quality (Panciera and Jung, 1984) and poor weed control (Martin et al., 1982; Mitchell et al., 2010). The stand failure of the warm-season grasses at the Williston dryland site, as compared with the success at the nearby irrigation site, suggest that establishment was constrained by the available soil water in the seeding year. This is in spite of the fact that these stands were the same with respect to seed batch, seeding strategy, weed control and soil characteristics.

At Hettinger, warm-season grasses seeded in 2006 showed stand failure in 2007, a warmer and drier than average year, followed by another stand failure in 2009, a wetter and colder year, of plots reseeded in 2008.

We see two possible explanations. First, the Hettinger area simply cannot support tall-statured warm-season grasses unless extra moisture is available due to topography or irrigation. Second, soil variability may contribute to stand failure due to problems with soil texture and salinity. Fortunately, intermediate wheatgrass may serve as an alternative for biomass production in these dry areas from the establishment perspective.

At Streeter and Minot, weed control was crucial to establishing warm-season grasses. For weed control in switchgrass and big bluestem stands, atrazine can be used pre-emergence (Hintz et al., 1998), and glyphosate can be used before spring growth of the warm-season grasses. During the

course of the six-year study period, warm-season grasses' composition increased, which may indicate the need to allow more time for these grasses to achieve optimum site occupancy.

Biomass yield of switchgrass in this region is highly variable: 1.4 to 5.6 tons/acre at Mandan and Dickinson, N.D. (Berdahl et al., 2005). 4.4 to 5.8 tons/acre in northeastern South Dakota (Boe and Lee, 2007), 0.9 to 4.0 tons/acre in central South Dakota (Lee and Boe, 2005). 3.0 to 5.8 tons/acre in southern Iowa (Lemus et al., 2002) and 3.6 to 8.9 tons/acre in Texas (Sanderson et al., 1999).

The cultivars of switchgrass we studied are all of the upland type but from different origins. Normally, southern-origin, later-maturing cultivars would produce more than northern-origin, early maturing cultivars (Casler et al., 2004). The more southern-origin cultivars may suffer from winterkill (Berdahl et al., 2005). However, the cultivar 'Dacotah' developed in North Dakota did not show superior stand establishment or production when compared with 'Sunburst,' a cultivar from South Dakota. 'Trailblazer,' also a southern cultivar, did show some stand decrease through the years at Streeter and Carrington where it was used. Its production was higher than 'Sunburst' only in 2007 at Carrington.

A trade-off occurs among different harvest regimes. A lower biomass yield would be expected with a biennial harvest regime, compared with annual harvests totaled for two years due to lodging and decomposition in the year without harvest. It is possible that the biennial harvest in a specific year will not necessarily be equal to the annual harvest in the same year due to biomass accumulation from the preceding year, residue effects on stand longevity and soil fertility, and soil water conservation.

Another aspect concerning annual vs. biennial harvest is the harvest cost and efficiency. The cost of two annual harvests is obviously higher than a biennial harvest. If we can improve the harvester to pick up more lodged material, the biennial harvest biomass yield will be higher than with the current machinery.

The primary reason for evaluating stubble height and its effect on biomass yield in this study was wildlife habitat. The best scenario is to select the appropriate species or mixtures that minimize yield lost due to high-stubble harvest while improving wildlife habitat. Also, researchers have shown that harvesting big-statured warm-season grasses at a very low-stubble height has a negative impact on their winter hardiness and the following year's biomass yield.

In the northern Great Plains, we harvest all forages with about a 3-inch stubble height to harvest the shorter forages. This may be too low for the selected switchgrass and big bluestem grass species. The question now is to decide how much producers would be affected by biennial or high-stubble harvesting and weighing that with environmental benefits when they grow bioenergy crops.

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Table 2. Seeded monoculture and mixture stand canopy cover (percent) at harvest (annual vs. biennial) of ten experimental entries for evaluating biomass yield for bioenergy at **Carrington**, North Dakota 2006 through 2013.

Harvest Year	Entries[1]									
	Sun-burst	Trail-blazer	Alkar	Haymaker	CRP1	CRP2	C_4C_31	C_4C_32	C_4C_41	C_3C_3
					Annual Harvest					
2007	100a[2]	100a	100a	100a	96a	87b	100a	100a	100a	96a
2008	100a	99ab	100a	99ab	97ab	82c	100a	100a	97ab	88abc
2009	100	100	100	100	100	100	100	100	100	100
2010	95	68	100	100	100	100	100	72	73	90
2011	70	70	100	100	100	100	100	100	100	98
2012	50	57	100	100	100	100	100	63	67	90
2013	60	53	63	100	97	93	87	53	70	60
					Biennial Harvest					
2009	100	100	100	100	100	100	100	100	100	100
2011	80	73	100	100	100	100	100	100	100	100
2013	47bc	30c	63abc	100a	97a	93a	57abc	80ab	37bc	80ab

[1] Experimental entry lists and abbreviations are shown in Table 1.
[2] Within rows for each harvest, means followed by the same letter are not significantly different according to LSD (0.05) for species yield.

Table 3. Seeded monoculture and mixture stand canopy cover (percent) at harvest (annual) of ten experimental entries for evaluating biomass yield for bioenergy at **Hettinger**, North Dakota 2006 through 2013.

Harvest Year	Entries[1]									
	Sunburst	Trailblazer	Alkar	Haymaker	CRP1	CRP2	C_4C_31	C_4C_32	C_4C_41	C_3C_3
					Annual Harvest					
2007	2c[2]	2c	80ab	86a	87a	78ab	70b	9c	4c	8c
2009	0c	7c	63ab	100a	100a	100a	83a	23bc	0c	40bc
2010	0d	0d	92a	82ab	70abc	67bc	50c	0d	0d	2d

[1] Experimental entry lists and abbreviations are shown in Table 1.
[2] Within rows for each harvest, means followed by the same letter are not significantly different according to LSD (0.05) for species yield.

Table 4. Seeded monoculture and mixture stand canopy cover (percent) at harvest (annual vs. biennial) of ten experimental entries for evaluating biomass yield for bioenergy at **Minot**, North Dakota 2006 through 2013.

Harvest Year	Entries[1]									
	Sunburst	Dacotah	Alkar	Haymaker	CRP1	CRP2	C_4C_31	C_4C_32	C_4C_41	C_3C_3
					Annual Harvest					
2007	35c[2]	18c	100a	100a	100a	100a	100a	67b	40bc	20c
2008	99a	83b	100a	100a	100a	100a	100a	95a	95a	93a
2009	100	83	100	100	100	100	100	100	100	100
2010	100	13	100	100	100	100	100	100	100	98
2011	100	60	98	100	100	100	100	97	100	100
2012	77bc	43d	73c	100a	100a	97ab	83abc	73c	83abc	63cd
2013	97a	57bc	43c	67abc	100a	100a	73abc	87ab	100a	50bc
					Biennial Harvest					
2009	100	83	100	100	100	100	100	100	100	100
2011	97	63	100	100	100	100	100	97	100	100
2013	97a	47b	83a	100a	100a	100a	77a	93a	100a	80a

[1] Experimental entry lists and abbreviations are shown in Table 1.
[2] Within rows for each harvest, means followed by the same letter are not significantly different according to LSD (0.05) for species yield.

Table 5. Seeded monoculture and mixture stand canopy cover (percent) at harvest (annual vs. biennial) of ten experiment entries for evaluating biomass yield for bioenergy at **Streeter**, North Dakota 2006 through 2013.

Harvest Year	Entries[1]									
	Sunburst	Trailblazer	Alkar	Haymaker	CRP1	CRP2	C_4C_31	C_4C_32	C_4C_41	C_3C_3
					Annual Harvest					
2007	33b[2]	2c	100a	100a	100a	100a	98a	10bc	15bc	3c
2008	33b	0b	100a	100a	100a	100a	100a	32b	37b	8b
2009	72a	0b	100a	100a	100a	100a	100a	73a	73a	0b
2010	93a	40bc	100a	100a	97a	100a	100a	80a	67ab	18c
2011	100a	80ab	67b	83ab	100a	100a	100a	100a	97a	0c
2012	100a	75ab	33bc	100a	100a	83a	75ab	60ab	100a	0c
2013	100a	93a	33d	90ab	87ab	83abc	63c	70bc	100a	0e
					Biennial Harvest					
2009	40c	2d	100a	100a	100a	100a	100a	73ab	60bc	0d
2011	100a	70ab	100a	63b	83ab	98a	100a	87ab	100a	0c
2013	100a	93ab	67bc	63bc	67bc	77ab	43c	43c	100a	0d

[1] Experimental entry lists and abbreviations are shown in Table 1.
[2] Within rows for each harvest, means followed by the same letter are not significantly different according to LSD (0.05) for species yield.

Table 6. Seeded monoculture and mixture stand canopy cover (percent) at harvest (annual vs. biennial) of ten experiment entries for evaluating biomass yield for bioenergy at **Williston - dry land**, North Dakota 2006 through 2013.

Harvest Year	Entries[1]									
	Sunburst	Dacotah	Alkar	Haymaker	CRP1	CRP2	$C_4C_3$1	$C_4C_3$2	$C_4C_4$1	C_3C_3
					Annual Harvest					
2007	32b[2]	28b	100a	100a	98a	100a	87a	15b	13b	17b
2008	3c	7bc	22b	88a	87a	99a	8bc	2c	0c	2c
2009	20b	20b	100a	100a	100a	100a	100a	20b	20b	20b
2010	33b	13bc	17bc	93a	100a	100a	5c	20bc	38b	0c
2011	53b	25bc	58ab	98a	98a	100a	33bc	33bc	35bc	0c
2012	63b	40b	7c	97a	100a	100a	40b	47b	57b	0c
2013	53bc	33cd	0e	90a	97a	90a	13de	40cd	77ab	0e
					Biennial Harvest					
2009	20b	20b	100a	100a	100a	100a	100a	20b	20b	20b
2011	33cd	33cd	42bc	100a	100a	98a	48bc	77ab	70abc	0d
2013	60bc	17d	7d	93ab	100a	90ab	23cd	57bc	83ab	0d

[1] Experimental entry lists and abbreviations are shown in Table 1.
[2] Within rows for each harvest, means followed by the same letter are not significantly different according to LSD (0.05) for species yield.

Table 7. Seeded monoculture and mixture stand canopy cover (percent) at harvest (annual vs. biennial) of ten experiment entries for evaluating biomass yield for bioenergy at **Williston - irrigated land**, North Dakota 2006 through 2013.

Harvest Year	Entries[1]									
	Sunburst	Dacotah	Alkar	Haymaker	CRP1	CRP2	$C_4C_3$1	$C_4C_3$2	$C_4C_4$1	C_3C_3
					Annual Harvest					
2007	100	100	100	100	100	100	100	100	100	100
2008	100	100	100	100	100	100	100	100	100	100
2009	100	100	100	100	100	100	100	100	100	100
2010	100a[2]	100a	100a	100a	100a	100a	100a	100a	100a	50b
2011	100	100	100	100	100	100	100	100	100	100
2012	100a	100a	67b	97a	90ab	93ab	66b	100a	100a	27c
2013	100a	100a	0c	83a	50b	33b	93a	100a	100a	33b
					Biennial Harvest					
2009	100	100	100	100	100	100	100	100	100	100
2011	100a	100a	100a	87b	93ab	87b	100a	100a	100a	100a
2013	100a	87ab	3d	43bcd	37cd	23d	77abc	100a	100a	43bcd

[1] Experimental entry lists and abbreviations are shown in Table 1.
[2] Within rows for each harvest, means followed by the same letter are not significantly different according to LSD (0.05) for species yield.

Table 8. Seeded monoculture and mixture stand canopy cover (percent) at harvest (annual vs. biennial) of ten experiment entries for evaluating biomass yield for bioenergy at **Mandan**, North Dakota 2009 through 2013.

Harvest Year	Entries[1]									
	Sunburst	Trailblazer	Alkar	Manifest	CRP1	CRP2	$C_4C_3$1	$C_4C_4$1	$C_4C_4$2	SD Native
					Annual Harvest					
2010	3b[2]	7b	90a	92a	77a	67a	72a	13b	0b	0b
2012	100a	100a	100a	100a	100a	100a	100a	87a	53b	0c
2013	100a	100a	100a	100a	100a	100a	100a	87b	30c	0d
					Biennial Harvest					
2013	100a	97a	100a	100a	100a	100a	100a	100a	37b	0c

[1] Experimental entry lists and abbreviations are shown in Table 1.
[2] Within rows for each harvest, means followed by the same letter are not significantly different according to LSD (0.05) for species yield.

Table 9. Seeded monoculture and mixture stand canopy cover (percent) at harvest (annual vs. biennial) of ten experimental entries for evaluating biomass yield for bioenergy at **Wing**, North Dakota 2009 through 2013.

Harvest Year	Entries[1]									
	Sunburst	Trailblazer	Alkar	Manifest	CRP1	CRP2	$C_4C_3$1	$C_4C_4$1	$C_4C_4$2	SD Native
					Annual Harvest					
2010	0b[2]	7b	83a	70a	93a	93a	73a	3b	2b	0b
2011	10bc	32b	100a	100a	100a	100a	100a	0c	20bc	0c
2012	63bc	83ab	100a	100a	100a	100a	100a	50cd	27de	0e
2013	67bc	90ab	100a	100a	100a	100a	100a	60c	30d	3d
					Biennial Harvest					
2011	20bc	7c	98a	67ab	100a	100a	100a	32bc	35bc	7c
2013	77ab	43bcd	100a	73abc	100a	100a	67abc	67abc	23cd	7d

[1] Experimental entry lists and abbreviations are shown in Table 1.
[2] Within rows for each harvest, means followed by the same letter are not significantly different according to LSD (0.05) for species yield.

Table 10. Seeded monoculture and mixture stand canopy cover (percent) at harvest (high vs. low stubble height) of ten experimental entries for evaluating biomass yield for bioenergy at **Streeter**, North Dakota 2009 through 2013.

Harvest Year	Entries[1]									
	Sunburst	Trailblazer	Alkar	Manifest	CRP1	CRP2	$C_4C_3$1	$C_4C_4$1	$C_4C_4$2	SD Native
					3-inch Low Stubble Harvest					
2010	67	62	35	93	73	50	75	40	48	3
2011	100a[2]	82ab	100a	100a	100a	100a	100a	83ab	60b	3c
2012	100a	90b	100a	100a	100a	100a	100a	100a	57c	0d
2013	100a	90a	93a	100a	100a	100a	100a	93a	57b	0c
					10-inch High Stubble Harvest					
2010	67abc	57abc	52abc	93a	87ab	72ab	83ab	45bcd	27cd	5d
2011	97a	98a	73b	100a	100a	93a	100a	97a	96a	2c
2012	100a	100a	100a	100a	97a	93a	100a	100a	68b	0c
2013	100a	100a	100a	100a	100a	100a	100a	100a	60b	0c

[1] Experimental entry lists and abbreviations are shown in Table 1.
[2] Within rows for each harvest, means followed by the same letter are not significantly different according to LSD (0.05) for species yield.

Table 11. Seeded monoculture and mixture stand canopy cover (percent) at harvest (high vs. low stubble height) of ten experimental entries for evaluating biomass yield for bioenergy at **Wing**, North Dakota 2009 through 2013.

Harvest Year	Entries[1]									
	Sunburst	Trailblazer	Alkar	Manifest	CRP1	CRP2	$C_4C_3$1	$C_4C_4$1	$C_4C_4$2	SD Native
					3-inch Low Stubble Harvest					
2010	7de[2]	3de	95a	43cd	93ab	57bc	100a	7de	0e	0e
2011	57b	30c	100a	100a	100a	100a	100a	53b	7d	2d
2012	90a	57b	100a	100a	100a	100a	100a	83ab	20c	8c
2013	100a	60b	100a	100a	100a	93a	100a	90a	17c	7c
					10-inch High Stubble Harvest					
2010	3b	3b	87a	87a	100a	97a	100a	0b	0b	0b
2011	60b	57b	100a	100a	100a	100a	100a	20c	30bc	0c
2012	83a	83a	100a	100a	100a	100a	100a	83a	10b	0b
2013	87a	87a	100a	100a	100a	100a	100a	60b	0c	3c

[1] Experimental entry lists and abbreviations are shown in Table 1.
[2] Within rows for each harvest, means followed by the same letter are not significantly different according to LSD (0.05) for species yield.

Table 12. Yield (ton/acre) at harvest (annual vs. biennial) of ten experiment entries for evaluating biomass yield for bioenergy at **Carrington**, North Dakota 2006-2013.

Harvest Year	Entries[1]									
	Sunburst	Trailblazer	Alkar	Haymaker	CRP1	CRP2	$C_4C_3$1	$C_4C_3$2	$C_4C_4$1	C_3C_3
					Annual Harvest					
2007	5.36abc[2]	**6.21a**[3]	4.66bcde	4.45cde	4.16de	4.93bcd	5.29abc	5.18bc	5.48ab	3.86e
2008	**5.13a**	4.57abc	4.37abc	3.35cd	3.75 bcd	3.79bcd	4.00abcd	4.96ab	4.86ab	3.12d
2009	**4.91a**	3.69cde	3.95bcd	3.22e	3.42de	3.23e	3.99bcd	4.43ab	4.21bc	3.11e
2010	4.04ab	3.39cde	**4.13a**	2.96de	3.23de	3.28de	3.47bcd	3.42bcd	3.95abc	2.76e
2011	4.19	4.28	4.54	3.53	**4.70**	4.33	4.19	4.19	4.26	3.61
2012	4.01	3.51	4.14	3.43	3.69	3.48	3.92	4.01	**4.23**	3.03
2013	2.85	2.11	2.28	2.87	2.79	2.52	2.25	2.92	**3.02**	2.51
7-year Average	**4.36a**	3.96ab	4.01ab	3.39cd	3.68 bcd	3.65bcd	3.88abc	4.16ab	4.29a	3.14d
					Biennial Harvest					
2009	5.36ab	4.02bc	4.04bc	3.42c	3.47c	3.18c	4.11bc	**5.76a**	5.24ab	3.08c
2011	4.66	4.85	4.82	4.38	3.83	3.88	4.84	5.13	**5.24**	3.84
2013	3.54	3.08	3.43	2.93	3.06	3.14	3.39	**4.48**	3.33	3.37
3-year Average	4.52ab	3.98bc	4.10bc	3.58c	3.45c	3.40c	4.11bc	**5.12a**	**4.61ab**	3.43c
					Ratio of Biennial/Annual					
2009/ 2008+2009	0.53	0.49	0.49	0.52	0.48	0.45	0.51	0.61	0.58	0.49
2011/ 2010+2011	0.57	0.63	0.56	0.67	0.48	0.51	0.63	0.67	0.64	0.60
2013/ 2012+2013	0.52	0.55	0.53	0.47	0.47	0.52	0.55	0.65	0.46	0.61
Average	0.54	0.55	0.52	0.55	0.48	0.49	0.57	0.64	0.56	0.57

[1] Experimental entry lists and abbreviations are shown in Table 1.
[2] Within rows for each harvest, means followed by the same letter are not significantly different according to LSD (0.05) for species yield.
[3] Bold number is the highest biomass yield within a year.

Table 13. Yield (ton/acre) at harvest (annual vs. biennial) of ten experiment entries for evaluating biomass yield for bioenergy at **Hettinger**, North Dakota 2007 through 2010.

Harvest Year	Entries[1]									
	Sunburst	Trailblazer	Alkar	Haymaker	CRP1	CRP2	C_4C_31	C_4C_32	C_4C_41	C_3C_3
					Annual Harvest					
2007	1.64d[2]	1.64d	2.32abcd	2.68ab	2.59ab	**2.86a**[3]	2.49abc	1.79cd	1.64d	1.93bcd
2009	1.51	1.06	1.11	1.64	1.34	**1.68**	1.52	1.60	1.43	1.30
2010	2.04	**2.43**	2.12	2.37	2.23	2.25	2.25	2.18	2.15	1.57
3-year Average	1.73	1.71	1.85	2.23	2.05	**2.26**	2.09	1.86	1.74	1.60

[1] Experimental entry lists and abbreviations are shown in Table 1.
[2] Within rows for each harvest, means followed by the same letter are not significantly different according to LSD (0.05) for species yield.
[3] Bold number is the highest biomass yield within a year.

Table 14. Yield (ton/acre) at harvest (annual vs. biennial) of ten experiment entries for evaluating biomass yield for bioenergy at **Minot**, North Dakota 2007 through 2013.

Harvest Year	Entries[1]									
	Sunburst	Dacotah	Alkar	Haymaker	CRP1	CRP2	C_4C_31	C_4C_32	C_4C_41	C_3C_3
					Annual Harvest					
2007	2.39b[2]	2.32b	4.19a	3.67a	4.47a	4.12a	**4.58a**[3]	2.29b	2.14b	2.35b
2008	1.63c	1.32c	4.10a	**4.13a**	3.58ab	3.23ab	4.09a	3.57ab	1.68c	2.47bc
2009	2.23	2.36	3.13	2.45	2.04	2.80	**3.25**	3.09	2.04	2.72
2010	3.48	**4.02**	3.32	2.73	2.10	2.88	3.45	3.22	3.82	2.77
2011	3.11	3.46	2.57	2.96	2.49	3.05	3.48	3.26	**3.58**	2.99
2012	1.90bc	1.96bc	1.38c	2.21bc	1.35c	**3.30a**	1.52bc	2.01bc	2.39ab	1.64bc
2013	2.72bc	2.63c	2.86bc	3.67ab	2.93bc	3.49abc	2.79bc	3.04bc	**4.30a**	3.24bc
7-year Average	2.49d	2.58cd	3.08abcd	3.12abc	2.71bcd	3.27ab	**3.31a**	2.93abcd	2.85abcd	2.60cd
					Biennial Harvest					
2009	4.33	3.21	**5.42**	3.76	4.08	4.19	5.33	4.38	3.59	4.20
2011	4.48ab	4.38ab	3.65bc	2.46d	2.69d	3.22cd	3.84bc	4.15b	**5.18a**	3.85bc
2013	4.33	3.48	2.35	3.11	2.68	3.54	2.56	3.30	**4.42**	3.12
3-year Average	4.38	3.69	3.81	3.11	3.15	3.65	3.91	3.95	**4.40**	3.73
					Ratio of Biennial/Annual					
2009/(2008+2009)	1.12	0.87	0.75	0.57	0.73	0.69	0.73	0.66	0.97	0.81
2011/(2010+2011)	0.68	0.59	0.62	0.43	0.59	0.54	0.55	0.64	0.70	0.67
2013/(2012+2013)	0.94	0.76	0.55	0.53	0.63	0.52	0.59	0.65	0.66	0.64
Average	0.87	0.70	0.66	0.51	0.65	0.58	0.63	0.65	0.74	0.71

[1] Experimental entry lists and abbreviations are shown in Table 1.
[2] Within rows for each harvest, means followed by the same letter are not significantly different according to LSD (0.05) for species yield.
[3] Bold number is the highest biomass yield within a year.

Table 15. Yield (ton/acre) at harvest (annual vs. biennial) of ten experiment entries for evaluating biomass yield for bioenergy at **Streeter**, North Dakota 2007 through 2013.

Harvest Year	Entries[1]									
	Sunburst	Trailblazer	Alkar	Haymaker	CRP1	CRP2	$C_4C_3$1	$C_4C_3$2	$C_4C_4$1	C_3C_3
					Annual Harvest					
2007	1.89c[2]	1.71c	3.42a	2.70b	3.38a	2.56b	**3.94a**[3]	1.79c	1.59c	1.67c
2008	1.66de	1.37e	2.63abc	2.74ab	2.67abc	1.65de	**3.09a**	2.10bcd	1.98cde	1.51de
2009	1.98	1.83	2.32	**3.31**	2.69	2.06	2.53	2.37	1.86	1.83
2010	2.72	2.70	**2.91**	2.82	2.58	2.36	2.75	2.18	2.19	2.15
2011	**4.34a**	2.33bc	2.38bc	2.64bc	2.80bc	2.57bc	2.62bc	3.39ab	2.83bc	2.24c
2012	**3.83a**	2.95b	1.06d	1.57cd	1.42cd	1.68cd	1.46cd	1.77c	3.30ab	1.08d
2013	**4.23a**	2.59b	1.50c	2.21bc	2.10bc	2.02bc	2.01bc	2.18bc	3.55a	1.39c
7-year Average	**2.95a**	2.21bc	2.32bc	2.57abc	2.52abc	2.13cd	2.63ab	2.25bc	2.47abc	1.70d
					Biennial Harvest					
2009	1.63ef	1.24f	4.02ab	2.86cd	3.55bc	2.99bcd	**4.75a**	2.78cd	2.77cd	2.51de
2011	3.97ab	2.50de	3.87abc	1.72e	2.83bcde	2.68bcde	**4.20a**	2.76bcde	3.73abcd	2.62cde
2013	**6.55a**	2.87c	2.23cd	1.69cd	2.07cd	2.61c	2.70c	1.87cd	4.62b	1.32d
3-year Average	**4.05a**	2.20d	3.37abc	2.09d	2.82bcd	2.76bcd	3.88a	2.47cd	3.71ab	2.15d
					Ratio of Biennial/Annual					
2009/ 2008+2009	0.45	0.39	0.81	0.47	0.66	0.81	0.85	0.62	0.72	0.75
2011/ 2010+2011	0.56	0.50	0.73	0.32	0.53	0.54	0.78	0.50	0.74	0.60
2013/ 2012+2013	0.81	0.52	0.87	0.45	0.59	0.71	0.78	0.47	0.67	0.53
Average	0.65	0.48	0.79	0.41	0.59	0.67	0.81	0.53	0.71	0.63

[1] Experimental entry lists and abbreviations are shown in Table 1.
[2] Within rows for each harvest, means followed by the same letter are not significantly different according to LSD (0.05) for species yield.
[3] Bold number is the highest biomass yield within a year.

Table 16. Yield (ton/acre) at harvest (annual vs. biennial) of ten experiment entries for evaluating biomass yield for bioenergy at **Williston dry land**, North Dakota 2007 through 2013.

Harvest Year	Entries[1]									
	Sunburst	Dacotah	Alkar	Haymaker	CRP1	CRP2	C_4C_31	C_4C_32	C_4C_41	C_3C_3
					Annual Harvest					
2007	0.83d[2]	0.91bcd	0.96bcd	**1.23a**[3]	1.04abc	0.87cd	1.06ab	0.87cd	0.90bcd	0.83d
2008	0.50	0.60	0.70	**0.79**	0.72	0.62	0.68	0.75	0.69	0.61
2009	0.93bc	0.84bc	1.05ab	**1.27a**	1.05ab	0.78c	0.93bc	0.85bc	1.00bc	0.90bc
2010	1.03	1.13	1.08	**1.32**	1.15	1.14	1.05	0.99	1.07	1.00
2011	1.95	1.92	1.62	**2.08**	1.72	1.97	1.58	1.75	1.93	1.69
2012	**1.45a**	1.09bcd	0.77e	1.09bcd	1.02cde	0.83de	0.92cde	1.11bc	1.30ab	0.91cde
2013	2.16a	1.34c	1.37c	1.75b	1.56bc	1.43bc	1.64bc	1.56bc	**2.24a**	1.42bc
7-year Average	1.26	1.12	1.08	**1.36**	1.18	1.09	1.12	1.13	1.30	1.05
					Biennial Harvest					
2009	1.35	1.16	1.16	1.22	**1.40**	0.95	1.24	1.31	1.15	1.22
2011	2.18	2.05	1.93	2.22	2.24	1.84	1.92	**2.68**	2.34	2.13
2013	1.81bcd	2.13ab	1.53d	1.66cd	1.75bcd	1.73bcd	1.73bcd	**2.53a**	2.03bc	1.48d
3-year Average	1.78	1.78	1.54	1.70	1.80	1.50	1.63	**2.17**	1.84	1.61
					Ratio of Biennial/Annual					
2009/(2008+2009)	0.94	0.81	0.66	0.59	0.79	0.68	0.77	0.82	0.68	0.81
2011/(2010+2011)	0.73	0.67	0.71	0.65	0.78	0.59	0.73	0.98	0.78	0.79
2013/(2012+2013)	0.50	0.88	0.71	0.58	0.68	0.77	0.68	0.95	0.57	0.64
Average	0.67	0.77	0.70	0.61	0.75	0.67	0.72	0.93	0.67	0.74

[1] Experimental entry lists and abbreviations are shown in Table 1.
[2] Within rows for each harvest, means followed by the same letter are not significantly different according to LSD (0.05) for species yield.
[3] Bold number is the highest biomass yield within a year.

Table 17. Yield (ton/acre) at harvest (annual vs. biennial) of ten experiment entries for evaluating biomass yield for bioenergy at **Williston irrigated land**, North Dakota 2007 through 2013.

Harvest Year	Entries[1]									
	Sunburst	Dacotah	Alkar	Haymaker	CRP1	CRP2	$C_4C_3$1	$C_4C_3$2	$C_4C_4$1	C_3C_3
					Annual Harvest					
2007	5.83a[2]	4.31bc	4.98ab	4.20bc	4.50bc	3.72c	5.61a	**5.85a**[3]	4.92ab	4.19bc
2008	**7.28a**	4.91c	3.16e	3.35e	3.24e	2.80e	4.27d	5.69b	5.87b	3.06e
2009	**5.76a**	4.09b	3.84b	3.72b	2.80c	3.48bc	3.92b	5.72a	5.02a	3.31bc
2010	5.33a	4.25bc	3.23def	2.51f	3.41cde	2.75ef	3.95cd	**5.44a**	5.11ab	3.43cde
2011	**5.62a**	3.93cd	3.08de	3.08de	3.21de	2.68e	4.67bc	5.59a	5.48ab	3.69d
2012	5.35a	3.67c	2.33ef	2.50ef	2.83de	1.89f	4.54b	**5.50a**	5.16ab	3.36cd
2013	5.02ab	3.24cd	2.51e	2.75de	2.75de	2.34e	4.52b	**5.33a**	5.01ab	3.71c
7-year Average	**5.74a**	4.06d	3.30e	3.16ef	3.25e	2.81f	4.50c	5.59ab	5.22b	3.54e
					Biennial Harvest					
2009	6.96a	5.43bc	5.48bc	3.93d	4.18cd	3.82d	6.12ab	**7.09a**	7.06a	6.57ab
2011	6.67a	5.22b	3.71d	3.40d	4.09bcd	3.77cd	4.94bc	**7.20a**	6.80a	4.58bcd
2013	**5.76a**	3.95c	2.13d	2.24d	2.21d	2.24d	4.45bc	5.32ab	5.58ab	4.38bc
3-year Average	6.46a	4.87b	3.77c	3.19c	3.49c	3.28c	5.17b	**6.54a**	6.48a	5.18b
					Ratio of Biennial/Annual					
2009/(2008+2009)	0.53	0.60	0.78	0.56	0.69	0.61	0.75	0.62	0.65	1.03
2011/(2010+2011)	0.61	0.64	0.59	0.61	0.62	0.69	0.57	0.65	0.64	0.64
2013/(2012+2013)	0.56	0.57	0.44	0.43	0.40	0.53	0.49	0.49	0.55	0.62
Average	0.56	0.61	0.62	0.53	0.57	0.62	0.60	0.59	0.61	0.76

[1] Experimental entry lists and abbreviations are shown in Table 1.
[2] Within rows for each harvest, means followed by the same letter are not significantly different according to LSD (0.05) for species yield.
[3] Bold number is the highest biomass yield within a year.

Table 18. Yield (ton/acre) at harvest (annual vs. biennial) of ten experiment entries for evaluating biomass yield for bioenergy at **Mandan**, North Dakota 2010 through 2013.

Harvest Year	Entries[1]									
	Sunburst	Trailblazer	Alkar	Manifest	CRP1	CRP2	$C_4C_3$1	$C_4C_4$1	$C_4C_4$2	SD Native
					Annual Harvest					
2010	2.45	2.28	**3.27**[3]	3.23	3.26	2.80	3.21	2.65	2.51	2.95
2012	1.52bc[2]	1.53bc	2.14a	**2.32a**	2.06a	1.88ab	2.06a	1.41bc	1.51bc	1.36c
2013	3.11	2.92	3.55	**3.85**	3.43	3.36	3.53	2.70	2.87	2.63
3-year Average	2.36	2.24	2.99	**3.13**	2.91	2.68	2.94	2.25	2.30	2.31
					Biennial Harvest					
2013	3.65b	3.52b	3.65b	3.49b	3.44b	3.35b	**5.05a**	3.01bc	2.93bc	2.30c
					Ratio of Biennial/Annual					
2013/ (2012+2013)	0.79	0.79	0.64	0.57	0.63	0.64	0.90	0.73	0.67	0.58

[1] Experimental entry lists and abbreviations are shown in Table 1.
[2] Within rows for each harvest, means followed by the same letter are not significantly different according to LSD (0.05) for species yield.
[3] Bold number is the highest biomass yield within a year.

Table 19. Yield (ton/acre) at harvest (annual vs. biennial) of ten experiment entries for evaluating biomass yield for bioenergy at **Wing**, North Dakota 2010 through 2013.

Harvest Year	Entries[1]									
	Sunburst	Trailblazer	Alkar	Manifest	CRP1	CRP2	$C_4C_3$1	$C_4C_4$1	$C_4C_4$2	SD Native
					Annual Harvest					
2010	1.42bc[2]	0.94c	2.13ab	1.24c	1.44bc	**2.36a**[3]	2.29a	0.94c	0.85c	1.08c
2011	1.72d	0.97d	**4.54a**	3.03c	3.88abc	3.38bc	4.33ab	1.35d	1.13d	0.83d
2012	1.89	2.14	**3.47**	2.55	2.70	2.86	3.27	1.25	1.50	1.68
2013	3.73abcd	3.97abcd	4.96ab	4.35abc	4.69abc	**5.11a**	5.07ab	2.78d	3.33cd	3.65bcd
4-year Average	2.19bcd	2.01cd	**3.77a**	2.79abc	3.18ab	3.43a	3.74a	1.58d	1.71d	1.81cd
					Biennial Harvest					
2011	1.14c	1.22bc	4.13a	2.52b	4.67a	4.65a	**4.75a**	1.75bc	1.24bc	1.00c
2013	3.89bc	3.37c	3.96bc	3.64c	**6.05a**	5.65ab	5.63ab	4.18bc	3.44c	2.56c
2-year Average	2.52c	2.30c	4.04ab	3.08bc	**5.36a**	5.15a	5.19a	2.96bc	2.34c	1.78c
					Ratio of Biennial/Annual					
2011/(2010+2011)	0.36	0.64	0.62	0.59	0.88	0.81	0.72	0.76	0.63	0.52
2013/(2012+2013)	0.69	0.55	0.47	0.53	0.82	0.71	0.68	1.04	0.71	0.48
Average	0.57	0.57	0.54	0.55	0.84	0.75	0.69	0.94	0.69	0.49

[1] Experimental entry lists and abbreviations are shown in Table 1.
[2] Within rows for each harvest, means followed by the same letter are not significantly different according to LSD (0.05) for species yield.
[3] Bold number is the highest biomass yield within a year.

Table 20. Yield (ton/acre) at harvest (high vs. low stubble height) of ten experiment entries for evaluating biomass yield for bioenergy at **Streeter**, North Dakota 2010 through 2013.

Harvest Year	Entries[1]									
	Sunburst	Trailblazer	Alkar	Manifest	CRP1	CRP2	$C_4C_3$1	$C_4C_4$1	$C_4C_4$2	SD Native
					3-inch Low Stubble Harvest					
2010	0.74bcd[2]	0.94abc	0.96abc	0.95abc	1.05abc	**1.17a**[3]	1.14ab	0.67cd	0.64cd	0.35d
2011	3.29ab	2.72bc	3.31ab	2.72bc	2.71bc	2.65bc	**3.70a**	3.10ab	2.17cd	1.55d
2012	3.00a	2.95a	1.56b	1.66b	1.70b	2.01b	1.85b	**3.57a**	1.51b	1.25b
2013	**3.88a**	2.84b	2.21bc	2.69b	2.49bc	2.38bc	2.45bc	3.88a	2.11bc	1.71c
4-year Average	2.73ab	2.36abc	2.01bc	2.01bc	1.99bcd	2.06abc	2.29abc	**2.80a**	1.61cd	1.22d
					10-inch High Stubble Harvest					
2010	0.39	0.29	0.25	**0.70**	0.33	0.47	0.42	0.17	0.30	0.08
2011	2.43a	2.37a	1.66ab	2.40a	1.55b	1.52b	**2.46a**	2.13ab	2.18ab	0.70c
2012	2.44ab	**2.86a**	0.71c	0.98c	0.69cd	1.14c	0.82c	2.25b	0.81c	0.21d
2013	2.77a	**2.90a**	1.34b	1.69b	1.62b	1.67b	1.40b	2.61a	1.17b	0.58c
4-year Average	2.01ab	**2.11a**	0.99de	1.44bcd	1.05de	1.20cd	1.27cd	1.79abc	1.12d	0.39e
					Ratio of High Stubble/Low Stubble					
2010	0.53	0.31	0.26	0.74	0.31	0.40	0.37	0.25	0.47	0.23
2011	0.74	0.87	0.50	0.88	0.57	0.57	0.66	0.69	1.00	0.45
2012	0.81	0.97	0.46	0.59	0.41	0.57	0.44	0.63	0.54	0.17
2013	0.71	1.02	0.61	0.63	0.65	0.70	0.57	0.67	0.55	0.34
4-year Average	0.74	0.89	0.49	0.72	0.53	0.58	0.56	0.64	0.69	0.32

[1] Experimental entry lists and abbreviations are shown in Table 1.
[2] Within rows for each harvest, means followed by the same letter are not significantly different according to LSD (0.05) for species yield.
[3] Bold number is the highest biomass yield within a year.

Table 21. Yield (ton/acre) at harvest (high vs. low stubble height) of ten experiment entries for evaluating biomass yield for bioenergy at **Wing**, North Dakota 2010 through 2013.

Harvest Year	Entries[1]									
	Sunburst	Trailblazer	Alkar	Manifest	CRP1	CRP2	$C_4C_3$1	$C_4C_4$1	$C_4C_4$2	SD Native
					3-inch Low Stubble Harvest					
2010	1.25d[2]	1.23d	**2.97a**[3]	1.54bcd	2.35abc	2.41ab	2.75a	1.09d	1.44cd	0.87d
2011	1.11d	1.82d	**4.75a**	3.14c	3.64bc	3.11c	4.50ab	1.44d	1.15d	1.29d
2012	2.21	1.78	2.83	1.85	2.01	**2.83**	2.31	1.83	1.77	1.75
2013	4.63ab	2.89c	4.82a	3.27bc	3.69abc	3.88abc	**4.90a**	3.62abc	3.25bc	2.76c
4-year Average	2.30cd	1.93d	**3.84a**	2.45cd	2.92bc	3.06abc	3.62ab	2.00d	1.91d	1.66d
					10-inch High Stubble Harvest					
2010	0.59b	0.66b	**2.00a**	1.20ab	1.23ab	1.86a	1.68a	0.70b	0.54b	0.45b
2011	1.07bc	0.89c	**3.78a**	1.92b	3.19a	3.35a	3.04a	0.45c	0.44c	0.41c
2012	1.32bc	1.19bc	1.58ab	1.49abc	1.62ab	**2.22a**	1.54abc	0.90bc	0.92bc	0.77c
2013	3.33abc	2.38bcd	**3.81a**	2.18cd	2.86abcd	2.88abcd	3.40ab	2.13d	1.80d	1.93d
4-year Average	1.58cde	1.28de	**2.79a**	1.70bcd	2.23abc	2.58a	2.42ab	1.05de	0.93e	0.89e
					Ratio of High Stubble/Low Stubble					
2010	0.47	0.54	0.67	0.78	0.52	0.77	0.61	0.64	0.38	0.52
2011	0.96	0.49	0.80	0.61	0.88	1.08	0.68	0.31	0.38	0.32
2012	0.60	0.67	0.56	0.81	0.81	0.78	0.67	0.49	0.52	0.44
2013	0.72	0.82	0.79	0.67	0.78	0.74	0.69	0.59	0.55	0.70
4-year Average	0.69	0.66	0.73	0.69	0.76	0.84	0.67	0.52	0.49	0.53

[1] Experimental entry lists and abbreviations are shown in Table 1.
[2] Within rows for each harvest, means followed by the same letter are not significantly different according to LSD (0.05) for species yield.
[3] Bold number is the highest biomass yield within a year.