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The values of warm-season native perennial grasses grown for pasture or biofuel in the southern Great Plains, USA

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Abstract. The Renewable Fuel Standard under the Energy Independence and Security Act of 2007 mandated the production of 136 billion liters of cellulosic biofuel by 2022. Switchgrass (*Panicum virgatum*) has been identified as a primary feedstock because it is a perennial, produces high yields and is adapted to a wide environmental range. Development of the cellulosic biofuel industry has been slow. A reason for this slow development is lack of available feedstock driven by lack of a developed market. Rather than considering switchgrass only as a dedicated biofuel feedstock, we examined its potential both for grazing and biofuel feedstock. In a series of experiments testing yield, grazing preference and animal gain; switchgrass (cv. Alamo) was found to produce greater total yield (17696 kg/ha) than fifteen other warm season perennial grasses, was the most preferred by stocker cattle in a grazing preference study and produced average daily gains in a grazing study (0.84-1.05 kg/hd). These results demonstrate the potential of switchgrass for both grazing and biofuel feedstock. However, the feedstock price would need to increase above $91/t before the economics of dedicated switchgrass feedstock production would surpass that of a combination of switchgrass grazing and feedstock production.

Keywords: Biofuel feedstock, switchgrass, grazing.

Introduction

Attempting to reduce United States (U.S.) foreign oil dependence, stabilize fuel prices and promote biofuel use, the Renewable Fuel Standard (RFS) was expanded under the Energy Independence and Security Act of 2007 (EISA). RFS mandated that by 2022 – 136 billion liters of biofuels be blended into transportation fuel. Of these 136 billion liters, 60 billion liters are mandated to be cellulosic biofuels (Bracmort 2012). Cellulosic biofuels are produced from biomass feedstocks that can originate as a by-product of an existing industry such as, wood chips from the forestry industry or from dedicated biomass crops, such as switchgrass, which is currently considered the standard perennial grass feedstock. To support the development of the cellulosic biofuel industry the U. S. federal government passed the Food, Conservation and Energy Act of 2008 as part of the 2008 farm bill. This act provided in excess of $1 billion to support and develop the cellulosic industry through research, grants, and guaranteed loans (Bracmort, *et al.* 2012). Currently there are several reasons for slow cellulosic biofuel industry development: cellulosic biofuels plants cost roughly three times more to construct than corn ethanol plants, investment risk in cellulosic biofuel plant development is considered high reducing available capital; cellulosic conversion technology is untested in large scale applications, and limited availability of feedstocks (Bracmort 2011). Driving the limitations associated with farmers willingness to grow feedstocks without a market that is competitive with their current crop and livestock enterprises (Griffith *et al.* 2012).

The objectives of this paper are: (1) to examine the suitability of native warm season grasses for feedstock production; (2) investigate biological and economic suitability of a feedstock produced for both grazing and biofuel; and (3) use biological study data to simulate the economics of cattle gain/bioenergy feedstock systems.

Methods

A series of experiments was conducted to examine the suitability of native warm season grasses for feedstock production and their suitability for feedstock and grazing. In Experiment 1, fifteen introduced and native warm season perennial grasses were placed in 3.0 m x 6.0 m plots and replicated three times to evaluate biomass yield, and yield distribution over a two year (2004, 2005) time period. Plots were harvested by species as each species reached boot stage of reproductive development. In Experiment 2, plots used for the yield and distribution study were subsequently used in a grazing preference study for three years (2006 – 2008). Three commercial (*Bos taurus*) stocker steers (250-300 kg) were grazed on the plot area for a total of 12 days each year over two grazing periods (June, July). Steers were given access to one replicate per day with each replicate grazed twice in each grazing period. Preference was determined by bite count by species. In Experiment 3, Switchgrass (cv. Alamo) was established and used in a stocker cattle grazing study to determine the value and utilization of switchgrass in a dual purpose animal gain and bioenergy feedstock system. In this study, stocker calves (381±89 kg) were placed onto 0.81-ha switchgrass paddocks at stock densities of 0 steers/ha (control), 2.5 steers/ha (light), 4.9 steers/ha (moderate), and 7.4 steers/ha

Table 1. Two-year average percent yield distribution by harvest month of total yearly dry matter yield of fifteen warm-season perennial grasses near Ardmore, OK, USA.

Variety/species	Harvest period May-June	August	Sept.-Oct.	Total DM yield (kg/ha)
Panicum virgatum (cv. Alamo)	43%	47%	10%	17696 a
Panicum coloratum (cv. Selection 75)	36%	48%	16%	14578 b
Cynodon dactylon (cv. Midland 99)	37%	45%	18%	13182 bc
Sorghum halepense (common)	37%	48%	15%	13075 bc
Pennisetum flaccidum (cv. Carostan)	36%	51%	13%	13027 bc
Eragrostis curvula (cv. Ermelo)	36%	44%	20%	12794 bc
Paspalum notatum (cv. Pensacola)	36%	42%	22%	11322 cd
Eragrostis curvula (cv. Morpa)	33%	46%	21%	11129 cd
Panicum virgatum (cv. Blackwell)	79%	21%	0%	9233 de
Sorghastrum nutans (cv. Lometa)	69%	0%	31%	9034 de
Paspalum dilatatum (common)	52%	18%	30%	8554 de
Bothriochloa bladhii (cv.WW-B. Dahl)	58%	0%	42%	8472 de
Panicum antidotale (cv. Blue)	14%	54%	32%	7520 ef
Bothriochloa ishaemum (cv. Plains)	72%	0%	28%	5258 f
Paspalum notatum (cv. Sand Mountain)	27%	22%	51%	5032 f

Letters in column indicate significant differences ($P \leq 0.05$).

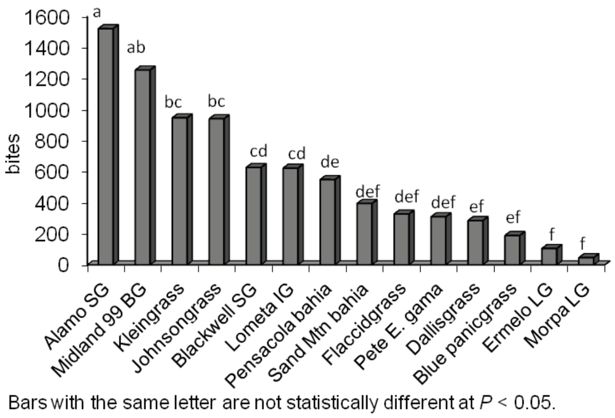

Figure 1. Average bite count rankings of warm season perennial grasses over a three year study near Ardmore, OK, USA.

(heavy). Grazing began when switchgrass reached 36 cm and ended when switchgrass height was 7.5 cm. After grazing, switchgrass was allowed to accumulate until after frost before harvested. The effect of grazing treatment on feedstock biomass was compared to the ungrazed control. In addition, data from this biological study were used to simulate the economics of seven alternative cattle gain/bioenergy feedstock systems.

Results

Experiment 1

Alamo switchgrass produced the highest average two year total dry matter yield with 43% of its total yield occurring in May-June. Kleingrass, bermudagrass, johnsongrass, flaccidgrass, and 'Ermelo' weeping lovegrass were all similar in yield with similar yield distribution to Alamo (Table 1). Many producers currently are growing these grasses in the Southern Plains. If cellulosic biofuel conversion technology advances to a point that these grasses could be utilized it would avoid the conversion of existing forage crops to switchgrass. Warm season perennial grasses that have potential for high total DM yield (>8000 kg/ha) with at least 1/3 of total yearly production occurring early (May-June) offer producers the potential of early season grazing or hay production followed by deferment for biofuel feedstock harvest (Rogers *et al.* 2012). This lowers producer risk if the biofuel feedstock market is low as the feedstock could be marketed through grazing or hay.

Experiment 2

Alamo switchgrass was the most preferred of fifteen warm season perennial grasses by bite count over the three year study (Fig. 1). Alamo switchgrass was the highest yield-ing of the grasses in the previous study (Table 1). Flaccidgrass and 'Ermelo' weeping lovegrass both of which were in the second statistical grouping in the yield study were in the lower statistical rankings of preference which would reduce their dual use potential.

Experiment 3

Grazing duration varied (80, 43 and 28 days) for light, moderate and heavy stock density treatments (P<0.05). Stock density had no effect on animal average daily gain (0.84-1.05 kg/hd). There was a trend (P=0.08) for greater total gain for moderate and high stock densities compared to light (Nichols *et al.* 2012). Light grazing decreased feedstock yield 31% compared to control (P<0.05) which was less than the reduction of moderate (47%) and heavy (49%) stock densities. Chicago Mercantile Exchange cattle futures prices were used to assign value of weight gain for each stock density treatment (Nichols *et al.* 2012). The value of animal weight gain varied by stock density due to differences in the grazing end dates. At feedstock valued at US$23/t or less, moderate grazing only with no feedstock production was the most economical system (Table 2). Conversely, when feedstock price reached US$91/t,

Table 2. Net returns and optimal system by stocking rate, value of gain and feedstock price.

	Stock density					
	Control	Low	Moderate	High		
Value of gain (US$/kg)	-	0.36	0.32	0.27		
Feedstock price	Net return $/ha				P > F	System
US$0/t	-40	1	7	-4	< 0.01	Moderate
US$23/t	-55	-9	-1	-12	< 0.01	Moderate
US$45/t	14	38	36	23	< 0.01	Low + feedstock
US$68/t	83	86	72	58	< 0.01	Low + feedstock
US$91/t	153	133	109	93	< 0.01	Feedstock
US$136/t	291	228	182	163	< 0.01	Feedstock
Breakeven (US$/t)	41	27	23	31	-	-

(Nichols *et al.* 2012)

producing feedstock only with no grazing was found to be the most economical system (Table 2).

Conclusion

Alamo switchgrass is a high yielding native warm season perennial grass with even yield distribution through the growing season. It is preferred grazing forage while vegetative and can produce good stocker cattle gain during early season grazing. High early season yield and quality and high total yield increase the utility of Alamo switchgrass beyond that of a dedicated biofuel feedstock. Profit potential of Alamo switchgrass is dependent upon feedstock and cattle price. Currently, the value of switchgrass feedstock is US$0/t. By moderately stocking switchgrass early in the growing season a moderate net return per acre is achievable with stocker cattle. Feedstock prices must exceed US$91/t for switchgrass feedstock to be the most economical without grazing.

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