Switchgrass as a Dual-Purpose Grazing and Bioenergy Crop

by Bryan Nichols, James Rogers, Jon Biermacher and Jagadeesh Mosali

Introduction
The Energy Independence and Security Act of 2007 set U.S. renewable fuel standards requiring the production of 16 billion gallons of ethanol from cellulosic biomass feedstocks by 2022. Switchgrass (Panicum virgatum L.), a native warm-season perennial grass, was evaluated by research funded through the United States Department of Energy as a primary cellulosic feedstock to achieve this goal. Switchgrass was identified because of its high biomass potential, perennial life-form and adaptability to marginal soils (McLaughlin and Kszos, 2005).

Switchgrass is grouped into two ecotypes, lowland and upland. Lowland switchgrass ecotypes (i.e., Alamo), in particular, have been identified as ideal feedstocks for the Southern Great Plains due to their adaptation to the region (Cassida et al., 2005). However, the expense and risk associated with establishment, maintenance and harvest of this crop combined with a lack of markets has prevented widespread adoption by landowners. In addition, biorefineries are reluctant to expend funds for the development of cellulosic refineries when production costs remain higher than costs for corn ethanol or other alternative fuels (Yaccobucci and Schnepf, 2007). Therefore, an alternative use for switchgrass is needed to encourage establishment as a potential feedstock in support of future biorefineries.

The stocker cattle industry is characterized by the development of young, lightweight calves on forage-based diets. As of Jan. 1, 2012, there were 1.59 million stocker cattle grazing small grains pastures (wheat, rye, etc.) in Oklahoma, Kansas and Texas (NASS, 2012). Traditionally, these forages are grazed from November through April, at which time cattle are either returned to the ranch for breeding purposes or moved to a feed yard for finishing prior to slaughter.

Up to 43% of lowland-type switchgrass total yield is produced in May, with crude protein measured above 10% (Rogers et al., 2012). Because of its early spring, high-quality forage production, switchgrass has the potential to be utilized in stocker grazing systems by complementing traditional cool-season annual forage systems and extending grazing through May. In addition, switchgrass possesses considerable regrowth potential following grazing, enabling significant end-of-season biomass production for use as bioenergy feedstocks (Anderson and Matches, 1983). The dual-use potential of this forage allows the producer an opportunity to diversify utilization of establishing switchgrass as biorefineries are developed.

Methods
In 2008, researchers at the Noble Foundation began a three-year study to determine the effects of grazing switchgrass at different stock densities in a dual-purpose stocker cattle grazing/bioenergy feedstock system. Switchgrass pastures used in this study were established in 2007 and had been in clean-tilled small grain production for the previous 25 years.
Steers used in this experiment had grazed cool-season annual rye pastures for a minimum of 100 days prior to the beginning of this trial and weighed an average of 765 pounds at grazing initiation. Treatments were four stock densities: control (no grazing; CON), low density (one steer per acre; LOW), moderate density (two steers per acre; MOD) and high density (three steers per acre; HIGH). Grazing began when plants reached a height of 14 inches. This initial grazing height was determined by researchers in Nebraska to result in optimal animal gains when grazing switchgrass (Anderson et al., 1988). Steers were removed from pastures when forage height was reduced to 3 inches or quality was deemed too low to support animal growth. The three-year average crude protein content of the LOW stocking density at grazing termination was 9.0%.

Results
By design, forage availability was not different among treatments at trial commencement and averaged 1,522 pounds per acre. Grazing began on April 21, May 7 and April 30 in 2008, 2009 and 2010, respectively. Forage quality was very good when grazing began and declined over the duration of the study with the most rapid decrease occurring over the first 28 days (Figures 1 and 2). As expected, grazing duration differed \((P < 0.05)\) among treatments (80, 43 and 28 days for LOW, MOD and HIGH, respectively).

Average daily gain of the LOW treatment tended to be less \((P = 0.12)\) than the MOD and HIGH treatments (Figure 3). Although forage intake was not measured, forage quality of the standing crop is reported in Table 1. Crude protein and total digestible nutrient content were greater for MOD and HIGH stocking densities compared to the LOW stocking density.

Table 1. Average forage quality during switchgrass grazing over three years

<table>
<thead>
<tr>
<th>Treatment</th>
<th>CP, %</th>
<th>TDN, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW</td>
<td>8.73\textsuperscript{a}</td>
<td>59.44\textsuperscript{a}</td>
</tr>
<tr>
<td>MOD</td>
<td>11.08\textsuperscript{b}</td>
<td>61.84\textsuperscript{b}</td>
</tr>
<tr>
<td>HIGH</td>
<td>10.45\textsuperscript{b}</td>
<td>62.77\textsuperscript{b}</td>
</tr>
</tbody>
</table>

\textsuperscript{1}LOW = one steer per acre; MOD = two steers per acre; HIGH = three steers per acre. \textsuperscript{a,b,c}Values with differing superscripts in a column differ \((P < 0.05)\).
LIVESTOCK

density ($P < 0.05$). Total gain per acre tended to be greater ($P = 0.08$) for MOD and HIGH treatments over the LOW stock density (Figure 4).

**Economics**

Production data collected from this experiment were used to determine the expected benefits and costs for seven grazing, feedstock, or grazing and feedstock systems for a range of cattle and feedstock price scenarios. The seven systems included: feedstock-only; three grazing-only systems at LOW, MOD or HIGH stock densities; and three systems representing grazing plus feedstock at LOW, MOD or HIGH stock densities.

Value of gain estimates were determined using 2011 CME cattle futures prices. Oklahoma custom rates for establishment and harvest costs published by the Oklahoma Cooperative Extension Service were used in the analysis (Doye and Sahs, 2011). Net returns to land, owner’s labor and management, and farm overhead are summarized in Table 2.

Value of gain for 2011 was 79 cents, 70 cents and 59 cents per pound for LOW, MOD and HIGH stock densities, respectively. These values are different because grazing

![Figure 3. Three-year average daily gain of steers grazing switchgrass ($P = 0.12$)](image)

![Figure 4. Three-year average total gain per acre of steers grazing switchgrass ($P = 0.08$)](image)

<table>
<thead>
<tr>
<th>Stocking Rate</th>
<th>CON</th>
<th>LOW</th>
<th>MOD</th>
<th>HIGH</th>
<th>$P &gt; F$</th>
<th>Optimal System</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011 CME Value of Gain ($/lb)</td>
<td>-</td>
<td>0.79</td>
<td>0.70</td>
<td>0.59</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Feedstock Price ($/ton)</td>
<td>Net Return ($/acre)</td>
<td>$0/ton</td>
<td>-98</td>
<td>3</td>
<td>18</td>
<td>-11</td>
</tr>
<tr>
<td>$25/ton</td>
<td>-137</td>
<td>-23</td>
<td>-2</td>
<td>-30</td>
<td>&lt; 0.01</td>
<td>MOD Graze-only</td>
</tr>
<tr>
<td>$50/ton</td>
<td>34</td>
<td>94</td>
<td>88</td>
<td>57</td>
<td>&lt; 0.01</td>
<td>LOW Graze + feedstock</td>
</tr>
<tr>
<td>$75/ton</td>
<td>206</td>
<td>212</td>
<td>179</td>
<td>143</td>
<td>&lt; 0.01</td>
<td>LOW Graze + feedstock</td>
</tr>
<tr>
<td>$100/ton</td>
<td>377</td>
<td>329</td>
<td>270</td>
<td>230</td>
<td>&lt; 0.01</td>
<td>Feedstock-only</td>
</tr>
<tr>
<td>$150/ton</td>
<td>719</td>
<td>564</td>
<td>450</td>
<td>403</td>
<td>&lt; 0.01</td>
<td>Feedstock-only</td>
</tr>
<tr>
<td>Breakeven ($/ton)</td>
<td>45</td>
<td>30</td>
<td>25</td>
<td>34</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

$^1$CON = no grazing; LOW = one steer per acre; MOD = two steers per acre; HIGH = three steers per acre.
duration was different between treatments, which affected the time of marketing. At these cattle prices, grazing only at a MOD stock density was the most profitable system with net returns of $20/acre for feedstock prices at or below $25/ton. At feedstock prices of $50/ton, the LOW stock density plus feedstock system was the most profitable choice, realizing a net return of $94/acre. Grazing was no longer economically competitive at a feedstock price between $75 and $100/ton. At $100/ton, net return was greatest for the feedstock-only system, which realized an average net return of $376/acre.

Conclusion
The results of this study indicate that the most economical grazing/feedstock system depends on both feedstock and cattle prices. We found that under 2011 cattle market conditions and assuming that a biorefinery does not currently exist in the region (the current price of feedstock is $0/ton), switchgrass should be grazed at a moderate stocking density (approximately 1.7 AUE/acre) for a duration of roughly 45 days. Under this market scenario, producers could earn a marginal profit of $20 per acre, which could be sustainable during the construction phase of a large-scale biorefinery. However, long-term success of the switchgrass grazing enterprise hinges significantly on a biorefinery's ability to purchase feedstock at a price between $50 and $75/ton. For this market scenario, producers could earn between $94 and $212 per acre by grazing switchgrass at a low stock density (0.85 AUE/acre) for approximately 80 days. In cases where a biorefinery offered a price of $100/ton or more, it would be most economical to produce only feedstock. Producers are encouraged to formulate budgets based on current market conditions before developing a grazing strategy.

Literature Cited

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