Effects of nitrogen fertilization and dried distillers grains supplementation: Forage use and performance of yearling steers


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ABSTRACT: In a 3-yr study, corn dried distillers grains plus solubles (DDGS) were evaluated as a substitute for forage and N fertilizer in yearling steers grazing smooth bromegrass. A total of 135 steers (330 ± 10 kg) were used in a randomized complete block design to measure the effects of DDGS supplementation and N fertilization on animal and pasture performance. Steers were initially stocked at 6.8 animal unit month (AUM)/ha on nonfertilized smooth bromegrass pastures (CONT), at 9.9 AUM/ha on smooth bromegrass pastures fertilized with 90 kg of N/ha (FERT), or at 9.9 AUM/ha on nonfertilized smooth bromegrass pastures with 2.3 kg of DDGS DM supplemented daily (SUPP). Paddock was the experimental unit, with 3 replications per year for 3 yr. Paddocks were strip-grazed and put-and-take cattle were used to maintain similar grazing pressure among treatment paddocks during the 160-d grazing season. In vitro DM disappearance declined quadratically (\(P < 0.01\)) throughout the grazing season. Crude protein was greater (\(P < 0.05\)) for FERT compared with CONT and SUPP. Standing crop was 18% greater (\(P < 0.01\)) for FERT than CONT and was 10% greater (\(P < 0.01\)) than SUPP. Adjusted stocking rates (AUM/ha) were greater (\(P < 0.01\)) for FERT and SUPP compared with CONT. Final BW were greater (\(P < 0.01\)) for SUPP steers compared with CONT and FERT steers. Similar results were observed for ADG, with SUPP steers gaining more (\(P < 0.01\)) compared with CONT and FERT steers. Total BW gain per hectare was increased (\(P < 0.01\)) by 53% with FERT and by 105% with SUPP. Feedlot ADG was similar among treatments (\(P = 0.88\)), and SUPP steers maintained their BW advantage through the finishing phase. Dried distillers grains can be used to substitute effectively for N fertilizer by increasing the performance of yearling steers grazing smooth bromegrass and increasing stocking rates compared with nonfertilized pastures.

Key words: dried distillers grain, nitrogen, smooth bromegrass, steer performance

INTRODUCTION

Historically, fertilization has been used to increase forage production relative to the cost of application. However, the relationship between energy costs, forage production, and animal performance is important to define to maximize returns in forage-based livestock production systems.

The amount of N applied as fertilizer to cool-season grasses is often in excess of plant uptake (Mosier et al., 2001) and the apparent N recovery rate can be as little as 17 to 50%. Additionally, limited amounts of N consumed by animals are removed from the ecosystem in animal products (Jarvis and Ledgard, 2002). The remaining portion may contribute to N losses, which can create excessive N in the environment. More effective management of N can serve to diminish both the cost of production and the environmental impact.

Actively growing forages contain protein that is highly degradable in the rumen, which can result in an MP deficiency and response to undegradable intake protein (UIP) supplementation (Klopfenstein et al., 2001; Creighton et al., 2003). Supplementing energy to forage-based ruminant diets can also improve performance and N-use efficiency (Lake et al., 1974; Fieser and Vanzant, 2004). Dried distillers grains are a good source of both energy and UIP.

Supplementation with DDGS (Morris et al., 2005; MacDonald et al., 2007; Loy et al., 2008) improves ADG of beef cattle grazing forages. Up to one-third of the response to DDGS may be due to meeting the MP needs of cattle (MacDonald et al., 2007).

In addition to the improvements in beef cattle performance, DDGS supplementation to grazing cattle has...
been shown to replace forage at 0.27 to 0.79 kg/kg of DDGS supplemented (Griffin et al., 2009). The objective of this experiment was to measure pasture productivity and growing cattle performance as affected by forage fertilization and animal supplementation strategies when cattle grazed smooth bromegrass.

**MATERIALS AND METHODS**

Steers were managed in accordance with the protocols approved by the Animal Care and Use Committee at the University of Nebraska.

**Experiment Site**

The experiment was conducted at the University of Nebraska-Lincoln Agricultural Research and Development Center near Mead, Nebraska (96°33′ W longitude, 41°11′ N latitude, 315 m elevation). The area is characterized by a continental climate with average maximum daily temperatures ranging from −0.3°C in January to 30.9°C in July. Average minimum daily temperatures range from −12.4°C in January to 17.8°C in July. The 10-yr average annual precipitation for this area was 693 mm (National Climatic Data Center, 2008), of which 75% fell in the form of rain from April through September. The most prominent soil type is a Sharpsburg silt clay loam (fine, montmorillonitic, mesic, Typic, Arguidoll). The predominant parent material is loess of Peorian age (Soil Conservation Service, 1965). The study site consisted of 3 pastures of smooth bromegrass, which, over the previous 10 yr, were fertilized annually with approximately 90 kg of N/ha and were grazed heavily in the months of May and October by calves and yearlings.

**Treatments**

Crossbred (predominantly Angus) steers (330 ± 10 kg) were used in a randomized complete block design with 3 blocks and 3 treatments. The treatments were 1) smooth bromegrass paddocks fertilized with 90 kg of N/ha and initially stocked with yearling steers at 9.2 animal unit month (AUM)/ha (FERT), 2) nonfertilized smooth bromegrass paddocks initially stocked at 6.4 AUM/ha (CONT), and 3) nonfertilized smooth bromegrass paddocks stocked at the same rate as the FERT with 2.3 kg of DM of corn DDGS supplemented daily per steer (SUPP). Morris et al. (2005, 2006) reported improvements in performance while maintaining complete consumption of the DDGS supplement at amounts of 0.5% of BW daily. In this experiment, steers were supplemented with 2.3 kg of DM of DDGS daily for the entire treatment period. This amount of supplementation was slightly greater (0.58% of average BW daily) than that reported by Morris et al. (2005, 2006). The stocking rate for the fertilized treatment was based on longer term stocking rate records for the site and University of Nebraska-Lincoln extension recommendations (Relm et al., 1971; Waller et al., 1986). For the nonfertilized treatment, previous research on smooth bromegrass pastures adjacent to the experimental pastures indicated 30% less available forage on nonfertilized compared with fertilized (90 kg of N/ha) smooth bromegrass (Schlueter, 2004).

**Paddock Management**

Within each of the 3 blocks, treatments were assigned randomly to 1 of 3 paddocks in 2005. Treatment allocation to the individual paddocks was the same for 2006 and 2007. Paddocks were 2.0 ha for FERT and SUPP and 2.9 ha for CONT, and were grazed from late April through September each of the 3 yr. Each paddock was further divided equally into 6 strips to implement intensive grazing management using rotational stocking. The cattle were rotated through all 6 strips in each paddock for all of the 5 grazing cycles. The period of stay was 4 d per strip in cycle 1 and 6 d per strip in cycles 2, 3, and 4. Period of stay in cycle 5 varied from 4 to 6 d based on available forage mass. Urea was used as the source of N fertilizer and was surface applied at 90 kg of N/ha to the designated paddocks 14 to 21 d before the initiation of grazing. A single-strand electric fence was used to define the perimeter of each strip and to confine steers to treatment groups.

In each of the 3 yr of the experiment, 45 crossbred steers (330 ± 10 kg) were blocked by BW and assigned randomly to the 9 paddocks. Five steers per paddock were used as test animals. A variable stocking density was used to maintain comparable grazing pressure among treatments and years. This was achieved with the addition and subtraction of put-and-take cattle. The number of put-and-take cattle varied among and within years based on the measured forage mass and visual observations. By doing so, the effects of the treatments on animal performance would be expressed from the total amount of BW gain per hectare while maintaining comparable pasture conditions. Animal days were calculated as the number of test steers multiplied by the number of days in the grazing period, plus the number of put-and-take cattle multiplied by the number of days the put-and-take cattle grazed within the grazing period. Total BW gain was then calculated by multiplying the ADG of the test steers by the total number of animal days. Put-and-take cattle were excluded from the animal performance data but were assumed to have similar intakes and BW gains as those of the steers on the experiment. Put-and-take cattle were of the same source as the test steers and were maintained on adjacent bromegrass pastures when not in use.

**Animal Management**

Steers were limit-fed a common diet at approximately 1.75% of BW daily for 5 d at the beginning and end
of the trial. The diet consisted of 48% alfalfa hay, 48% wet corn gluten feed, and 4% supplement (DM basis) that contained vitamins and minerals. Body weights of limit-fed cattle were measured for 3 consecutive days to minimize the impact of variation in gut fill. Group BW were taken on site with a mobile pen scale (MASM7-20EA, Norac Inc., Fridley, MN) at approximately 0800 h after the completion of cycles 1, 2, 3, and 4. Group BW were assigned a 4% shrink. Portable water tanks and feed bunks were located on a single-lane gravel road that bordered each strip. Cattle were checked daily according to site standard operating procedures (approved by the Institutional Animal Care Committee) and were provided free-choice trace mineral salt blocks and fresh water at all times.

After the completion of the study, steers were finished on high-concentrate diets containing high-moisture corn, dry-rolled corn, corn milling by-products, mixed hay, and a finely ground corn-based meal supplement. Steers were implanted with a terminal estrogenic-trenbolone acetate implant (Synorex-Choice, Fort Dodge Animal Health, Overland Park, KS) and fed diets to provide 320 mg of monensin (Elanco Animal Health, Greenfield, IN) daily and 90 mg of tylosin (Elanco Animal Health) daily. Metabolizable protein, Ca, P, and K were formulated to meet or exceed NRC (1996) requirements. Finishing diets were similar within year but changed slightly across the 3 yr. Steers were not maintained in their original treatment groups within finishing pens. Therefore, the effects of pasture treatment on finishing DMI and G:F are not available, but the effect of treatment on ADG was determined. On average, steers were fed for 109 d. On the day of shipping, steers were fed 50% of the DM offered the previous day and were shipped at 2000 h. Steers were slaughtered at 0630 h the following day at a commercial packing plant (Greater Omaha Pack, Omaha, NE), where HCW were recorded. After a 48-h chill, 12th-rib fat thickness and USDA-called marbling score were recorded. Carcass weight and animal measurements, except for 12th-rib fat and

**Data Collection and Analysis**

Paddock measurements were made in the second, fourth, and sixth strips in paddocks of block 1, 2, and 3, respectively, in each cycle, resulting in different collection dates for each block. Blocks were sampled on different dates because of the labor and time demands associated with the intensive diet and forage measurement procedures. Diet samples were collected at the midpoint of a grazing period from 2 steers fitted with rumen cannulae. Briefly, steers were fasted for 12 h and ruminally evacuated at 0800 h on each sampling day. Steers were given 30 min to graze the assigned paddock. Masticate samples were removed from the rumen and immediately put on ice, and rumen contents were returned to the rumen. Samples were transported on ice to the laboratory after collection and frozen at −4°C until they were lyophilized (−50°C). The dried samples were ground individually through a Wiley mill (Thomas Scientific, Swedesboro, NJ) fitted with a 2-mm screen; a subsample was ground through a 1-mm screen. In vitro DM disappearance was determined for diet samples using the method of Tilley and Terry (1963) modified by the addition of 1 g/L of urea to the McDougal buffer (Weiss, 1994). Rumen fluid was collected from 2 ruminally fistulated steers provided ad libitum access to smooth bromegrass hay.

Five forage standards of varying qualities and known in vivo DM digestibilities were included in all of the IVDMD runs. The IVDMD values for these standards were regressed on their known digestibilities to develop regression equations for each run to correct the IVDMD values to in vivo values. This method for correcting to in vivo values was described by Geisert et al. (2006). Crude protein was determined for diet samples by the combustion method (AOAC, 1996), using a combustion N analyzer (Leco FP-528, Leco, St. Joseph, MI).

Pregrazing standing crop was estimated the day before cattle were moved into a strip that was to be used for diet collection. The drop disc method was used (Sharrow, 1984; Karl and Nicholson, 1987). Fifty disc (0.26 m²) measurements were taken at randomly selected locations in each strip and correlated to actual clipped data from quadrats (0.38 m²) placed immediately below every eighth disc location. Standing crop at the end of the fifth cycle (i.e., end of grazing season) also was estimated using the drop disc method in 2005. Our goal was to leave approximately 1,200 kg/ha of standing crop at the end of the fifth cycle. Postgrazing standing crop for the fifth cycle in 2005 was approximately 1,200 kg/ha and was equivalent to a 10-cm stubble height. Grass stands in all paddocks were grazed to an approximate 10-cm stubble height in 2006 and 2007.

Data were analyzed using the MIXED procedures (SAS Inst. Inc., Cary, NC) as a randomized complete block design, with block considered as a random effect. Model effects were year, treatment, the year × treatment interaction, cycle, and the cycle × treatment interaction. Repeated measures were used to test the effects of time (cycle). Paddock was the experimental unit for diet sample measurements, steer performance, and steer carcass characteristics. Regression equations were developed using the solution options in SAS, with the greatest order polynomials that were significant ($P < 0.05$) included in the equation.

**RESULTS AND DISCUSSION**

No year × treatment interactions were detected ($P > 0.20$), so the main effects of treatment are reported. A year effect ($P < 0.01$) was detected for all forage and animal measurements, except for 12th-rib fat and
marbling. The year effect was most likely due to environmental conditions and the differences in initial steer BW among years. The cumulative annual precipitation varied among years of the study, with 2007 being an exceptionally wet year (Table 1). In eastern Nebraska, a large proportion of the annual rainfall occurs in the spring, declines through the summer, and increases again in August and early fall. However, the amount of rainfall received after August is less predictable.

A cubic ($P < 0.01$) response was observed for standing crop throughout the grazing season (Table 2). Stocking rate (AUM/ha) also showed a cubic response, with the greatest values in the last cycle of the season because of an increase in BW and increased grazing pressure. The increase in grazing pressure in the last cycle was mainly a function of increasing the number of put-and-take animals to arrive at the end-of-season standing crop target of 1,200 kg/ha or a 10-cm stubble height. Crude protein showed a cubic response ($P < 0.01$) during the growing season (Table 2). In vitro DM digestibility declined quadratically ($P < 0.01$). Crude protein and IVDMD results were similar to other reported values (Schlueter, 2004; MacDonald et al., 2007) from similar monoculture brome pastures at this location.

Supplementation and fertilization had an effect ($P < 0.01$) on CP content of diets; however, IVDMD did not differ ($P = 0.72$) by treatment (Table 3). Crude protein content was greatest ($P < 0.05$) for FERT and was not different between SUPP and CONT. Mean pregrazing standing crop was 18% greater ($P < 0.01$) for FERT than CONT and 10% greater ($P < 0.01$) than SUPP (Table 3). Stocking rates were greater ($P < 0.01$) for FERT and SUPP (13.38 and 13.96 AUM/ha, respectively) compared with CONT (8.69 AUM/ha). The fertilized paddocks had a 54% greater stocking rate than CONT. Therefore, total BW gain (kg/ha; Table 4) was greater for FERT and SUPP compared with CONT. Our initial stocking rate on fertilized paddocks was based on a 45% increase in forage production relative to nonfertilized paddocks. We were able to adjust for the increase in pasture production with the put-and-take cattle. The measure of this success is evident in the equal BW gains observed in the FERT and CONT treatments. If adjustments in stocking rates were not successful, performance differences between FERT and CONT would have been likely because of limited forage intake from overstocking or increased forage quality and selectively from understocking.

Organic matter and N are returned to the soil through feces and urine, which can help bolster pasture conditions. Urine excreted on actively growing pastures has been shown to increase forage production in the immediate area of the spot of urination (Doak, 1952; Ball and Ryden, 1984). Concentrations of N in the immediate area of the urine patch can be equivalent to an application of 100 to 400 kg of N/ha (Ball and Ryden, 1984; Haynes and Williams, 1993). More recently, Watson et al. (2000) reported that the uneven deposition of excreta N by grazing livestock can lead to spot application rates equivalent to 400 to 2,000 kg of N/ha. By comparison, corn typically receives only 100 to 200 kg of N/ha (David et al., 1997). This rate is 10-fold greater than the rate used in our fertilized pastures and the rate commonly recommended for smooth bromegrass pastures in Nebraska. The effect of urine on grassland soils and production in the deposition area is dependent on the N concentration of the urine, the volume of urine, and several soil factors, including the infiltration rate into the soil (Whitehead, 1995).

The area surrounding the urine patch is also often influenced, depending on the lateral root growth adja-

Table 1. Cumulative precipitation (mm) during the growing season in 2005, 2006, and 2007

<table>
<thead>
<tr>
<th>Month</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>10-yr average</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>205</td>
<td>239</td>
<td>240</td>
<td>165</td>
</tr>
<tr>
<td>May</td>
<td>274</td>
<td>274</td>
<td>415</td>
<td>270</td>
</tr>
<tr>
<td>June</td>
<td>362</td>
<td>299</td>
<td>477</td>
<td>352</td>
</tr>
<tr>
<td>July</td>
<td>463</td>
<td>376</td>
<td>519</td>
<td>420</td>
</tr>
<tr>
<td>August</td>
<td>482</td>
<td>532</td>
<td>777</td>
<td>524</td>
</tr>
<tr>
<td>September</td>
<td>507</td>
<td>691</td>
<td>853</td>
<td>595</td>
</tr>
</tbody>
</table>

1National Climatic Data Center (Asheville, NC) for Mead, Nebraska (http://cdo.ncdc.noaa.gov/ancsum/ACS; accessed Jan. 25, 2008).

Table 2. Main effects of season (day) on diet sample characteristics and pregrazing standing crop of smooth bromegrass paddocks grazed by yearling steers

<table>
<thead>
<tr>
<th>Item</th>
<th>Julian day$^1$</th>
<th>SEM</th>
<th>P-value$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>119</td>
<td>149</td>
<td>183</td>
</tr>
<tr>
<td>IVDMD,$^3$ %</td>
<td>71.6</td>
<td>63.0</td>
<td>54.8</td>
</tr>
<tr>
<td>CP, %</td>
<td>18.8</td>
<td>14.4</td>
<td>13.3</td>
</tr>
<tr>
<td>Standing crop, kg/ha</td>
<td>2,302</td>
<td>3,501</td>
<td>2,647</td>
</tr>
<tr>
<td>Stocking rate, AUM$^4$/ha</td>
<td>7.84</td>
<td>12.37</td>
<td>12.10</td>
</tr>
</tbody>
</table>

1Julian day is the average day within the cycle for the 3-yr period.
2Probabilities of linear, quadratic, and cubic trends determined with orthogonal polynomial contrasts.
3Corrected IVDMD values were determined by including 5 hay samples of varying qualities with known total tract in vivo digestibility. The IVDMD values for these standards were regressed on their known digestibility to develop an equation to calculate IVDMD values within each in vitro run.
4Animal unit month.
cent to the affected area. This too can have impacts on forage production. In tall fescue (*Festuca arundinacea* Schreb.) pastures, the immediate area affected by cows (0.9 to 1.2 m²; Lotero et al., 1966) has been reported to be more than double the area covered by urination (0.2 to 0.5 m²; Haynes and Williams, 1993). Whitehead (1995) estimated that with an average area of 0.4 m², and assuming no spatial overlap, urine coverage would amount to approximately 24% of the grazing unit per year. Grazing distribution and management can also contribute to the spatial coverage of urine deposits. Although intensive grazing management generally is used to control forage utilization, it also minimizes patchiness in urine spots because of more uniform urine distribution. In continuous grazing systems, urine distribution can be concentrated around areas of greater activity.

The relatively greater performance of the SUPP steers is likely due to the consistent supply of high-quality DDGS throughout the grazing season. The SUPP stocking rate was comparable with FERT and greater than CONT. The favorable stocking rate suggests that the DDGS was replacing some forage or that the grass productivity of the SUPP paddocks was increased from excess N excretion, as described previously, or both. Loy et al. (2008) found DDGS to have a forage substitution rate of 0.4 kg of forage/kg of DDGS. Likewise, Griffin et al. (2009) summarized 6 trials from individually fed animals that suggested forage replacement to be approximately 0.5 kg of forage/kg of DDGS. Both of these studies indicate more favorable stocking rates with DDGS supplementation.

Final BW was increased (*P < 0.01) by 37 and 40 kg for SUPP steers compared with CONT and FERT steers, respectively (Table 4). Final BW for CONT and FERT steers did not differ (*P = 0.69; 440 and 437 kg, respectively). Similar results were observed for ADG, with SUPP steers gaining more (*P < 0.01; 0.92 kg/d) compared with CONT and FERT steers (0.68 and 0.67 kg/d, respectively). Total BW gain per hectare increased (*P < 0.01) by 53% for FERT and more than

### Table 3. Main effects of supplementation with dried distillers grains and N fertilization on diet sample characteristics and pregrazing standing crop of smooth bromegrass paddocks grazed by yearling steers

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CONT</td>
<td>FERT</td>
</tr>
<tr>
<td>IVDMD, %</td>
<td>60.5</td>
<td>59.7</td>
</tr>
<tr>
<td>CP, %</td>
<td>15.0c</td>
<td>17.3b</td>
</tr>
<tr>
<td>Standing crop, kg/ha</td>
<td>2,302a</td>
<td>2,722b</td>
</tr>
<tr>
<td>Stocking rate, AUM/ha</td>
<td>8.69d</td>
<td>13.38e</td>
</tr>
</tbody>
</table>

* a–cMeans in a row without a common superscript differ (*P < 0.05).
* d,eMeans in a row without a common superscript differ (*P < 0.01).
* 1Paddocks were nonfertilized (CONT), fertilized with N at 90 kg of N/ha (FERT), or nonfertilized and steers were supplemented with 2.3 kg of dried distillers grains plus solubles DM (30.4% CP) daily for the entire gazing period (SUPP).
* 2TRT = treatment.
* 3Corrected IVDMD values were determined by including 5 hay samples of varying qualities with known total tract in vivo digestibility. The IVDMD values for these standards were regressed on their known digestibility to develop an equation to calculate IVDMD values within each in vitro run.
* 4Animal unit month.

### Table 4. Main effects of grazing management and supplementation strategies on performance for steers grazing smooth bromegrass

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CONT</td>
<td>FERT</td>
</tr>
<tr>
<td>Animal days</td>
<td>834</td>
<td>897</td>
</tr>
<tr>
<td>Area, ha</td>
<td>2.90</td>
<td>2.01</td>
</tr>
<tr>
<td>Initial BW, kg</td>
<td>330</td>
<td>329</td>
</tr>
<tr>
<td>Final BW, kg</td>
<td>440b</td>
<td>437b</td>
</tr>
<tr>
<td>BW gain, kg</td>
<td>110b</td>
<td>108b</td>
</tr>
<tr>
<td>BW gain, kg/ha</td>
<td>197b</td>
<td>302b</td>
</tr>
<tr>
<td>ADG, kg/d</td>
<td>0.68b</td>
<td>0.67a</td>
</tr>
</tbody>
</table>

* a–cMeans in a row without a common superscript differ (*P < 0.01).
* 1Paddocks were nonfertilized (CONT), fertilized with N at 90 kg of N/ha (FERT), or nonfertilized and steers were supplemented with 2.3 kg of dried distillers grains plus solubles DM (30.4% CP) daily for the entire gazing period (SUPP).
* 2TRT = treatment.
* 3Animal days calculated as the number of steers multiplied by the number of days in the grazing period, plus the number of put-and-take cattle multiplied by the number of days the put-and-take cattle grazed within the grazing period.
* 4Shrunk weight; steers were limit-fed for 5 d immediately before measuring initial and final BW.
* 5Calculated by multiplying ADG by the total number of animal days, and then dividing by the number of hectares.
doubled for SUPP (105%) compared with CONT (197 vs. 404 kg/ha). This dramatic effect on BW gain per hectare for the SUPP steers was due to the increase in both stocking rate and animal performance. The large increase in BW gain per hectare for the FERT steers was solely due to the 54% increase in stocking rate because animal performance between the CONT and FERT steers was similar ($P = 0.95$).

Interim pen BW data showed a quadratic ($P < 0.01$) decrease in cumulative ADG for both the supplemented and nonsupplemented cattle over the entire grazing period (Figure 1). The overall decrease in ADG throughout the grazing period is indicative of diet quality. Digestibility of cool-season grasses generally declines with maturity. However, because of the characteristic regrowth often observed in the later portion of the grazing season, a quadratic response is often observed in digestibility, and ADG tends to respond accordingly. The response, or difference between the supplemented and nonsupplemented steers, increased quadratically ($P < 0.01$) over the grazing period, suggesting the response is inversely related to the decrease in diet quality. This unique observation is possibly due to the protein and energy response later in the grazing period being greater than the UIP response during the earlier portion of the grazing period. The observed response in the early portion of the grazing period (Figure 1) is similar to typical responses from UIP supplementation (0.14 kg/d). Energy would not be limited during this time, but as diet quality diminishes, both protein and energy would contribute to the increased response.

MacDonald et al. (2007) attributed the increase in performance to the energy from both fat and UIP when cattle were supplemented with DDGS. Dried distillers grains also may contribute to performance in growing cattle because of the response often observed from UIP supplementation attributable to an MP deficiency (Creighton et al., 2003). Loy et al. (2008) found DDGS to have an 18 to 30% greater energy value than dry-rolled corn supplemented to heifers consuming low-quality forages (8.2% CP; 56% in vitro OM disappearance), with a forage substitution rate of 0.4 kg of forage/kg of DDGS. MacDonald et al. (2007) evaluated heifers on similar pastures and showed a greater response from feeding DDGS compared with corn gluten meal or corn oil. The slope of the response to corn gluten meal was 39% of the slope of the DDGS, indicating that a portion of the DDGS response may be due to meeting an MP deficiency (MacDonald et al., 2007).

Griffin et al. (2009) summarized 14 grazing experiments to evaluate the performance of growing calves supplemented with DDGS. In the summary, ADG were increased by 0.23 kg/d for supplementation of 0.5% of BW daily. These studies showed a response greater than what is typically observed from supplementing UIP (0.14 kg/d; Creighton et al., 2003). Once the protein requirements are met, the additional BW gain can be attributed to the concentrated energy from DDGS.

The finishing performance of steers in yr 1 and 2 is shown in Table 5. Initial BW for SUPP steers were heavier ($P < 0.01$) than those of CONT and FERT steers. Daily BW gain was similar among treatments ($P = 0.88$), indicating that no compensatory response from the grazing phase carried over into the finishing phase. Therefore, the BW advantage of SUPP from the grazing phase was maintained throughout the finishing phase. The BW advantage from SUPP was also observed in HCW, with SUPP steers having 6.3% heavier ($P < 0.01$) carcasses. Seventy percent of the BW transfer from BW gain was in carcass weight, making the value of SUPP greater if cattle were retained through the finishing phase and marketed on a carcass basis. Individual intakes and feed conversions were not available for these steers in the feedlot. Morris et al. (2006)
Table 5. Main effects of grazing management and supplementation strategies on feedlot performance and carcass characteristics for steers grazing smooth bromegrass

<table>
<thead>
<tr>
<th>Item</th>
<th>CONT</th>
<th>FERT</th>
<th>SUPP</th>
<th>SEM</th>
<th>TRT × year</th>
<th>TRT</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days</td>
<td>109</td>
<td>109</td>
<td>109</td>
<td>3</td>
<td>0.87</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Initial BW, kg</td>
<td>457&lt;sup&gt;a&lt;/sup&gt;</td>
<td>456&lt;sup&gt;a&lt;/sup&gt;</td>
<td>494&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3</td>
<td>0.87</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Final BW, kg</td>
<td>648&lt;sup&gt;a&lt;/sup&gt;</td>
<td>648&lt;sup&gt;a&lt;/sup&gt;</td>
<td>689&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7</td>
<td>0.22</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>ADG, kg</td>
<td>1.75</td>
<td>1.77</td>
<td>1.79</td>
<td>0.05</td>
<td>0.28</td>
<td>0.88</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>HCW, kg</td>
<td>411&lt;sup&gt;a&lt;/sup&gt;</td>
<td>412&lt;sup&gt;a&lt;/sup&gt;</td>
<td>437&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.07</td>
<td>0.25</td>
<td>0.12</td>
<td>0.06</td>
</tr>
<tr>
<td>Marbling score</td>
<td>545&lt;sup&gt;c&lt;/sup&gt;</td>
<td>530&lt;sup&gt;c&lt;/sup&gt;</td>
<td>603&lt;sup&gt;d&lt;/sup&gt;</td>
<td>18</td>
<td>0.61</td>
<td>&lt;0.01</td>
<td>0.18</td>
</tr>
</tbody>
</table>

<sup>a,b</sup>Means without a common superscript differ (P < 0.01).  
<sup>c</sup>Means without a common superscript differ (P < 0.05).  
<sup>1</sup>Individual intakes not available during the feedlot phase.  
<sup>2</sup>Paddocks were nonfertilized (CONT), fertilized with N at 90 kg of N/ha (FERT), or nonfertilized and steers were supplemented with 2.3 kg of dried distillers grains plus solubles DM (30.4% CP) daily for the entire grazing period (SUPP).  
<sup>3</sup>TRT = treatment.  
<sup>4</sup>Limit-fed BW were the average of 2 consecutive days after a 5-d limit-fed period.  
<sup>5</sup>Carcass-adjusted final BW, calculated from HCW, adjusted by a common dressing percentage of 63.5%.  
<sup>6</sup>Where 500 = Small 0, 600 = Modest 0.

showed no difference in feedlot feed efficiency when cattle were supplemented with DDGS during the grazing period.

In conclusion, DDGS increased performance when steers were grazing smooth bromegrass pastures. The performance advantage in BW (37 kg) was carried through the finishing phase. Nitrogen fertilization of smooth bromegrass pastures increased forage production, CP content, and stocking rate, but did not influence steer performance. Supplementing yearling steers with DDGS can result in a stocking rate similar to that of steers grazing N-fertilized pastures while realizing a 34% increase in total gain per hectare. Total BW gain per hectare increased by 53% with fertilization and by 105% with supplementation compared with nonfertilized pastures and nonsupplemented steers. Dried distillers grains can be used to substitute effectively for N-fertilized pastures by increasing performance and BW gain per hectare of yearling steers grazing smooth bromegrass in eastern Nebraska.

**LITERATURE CITED**


