# Replacing Fertilizer Nitrogen with Dried Distillers Grains Supplement to Yearling Steers Grazing Bromegrass Pastures: Daily Gain and Nitrogen Use Efficiency

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## Summary

*In a three-year study, corn-dried distillers grains plus solubles (DDGS) were evaluated as a substitute for forage and nitrogen (N) fertilizer in yearling steers grazing smooth bromegrass in eastern Nebraska. Stocking rate increased with N fertilization and DDGS, and average daily gain (ADG) increased with DDGS. Total gain per acre increased by 53% with N fertilization and 105% with DDGS supplementation. N use efficiency was 139% greater per acre with DDGS supplementation compared to fertilizing with N alone. Feedlot ADG was similar among treatments with steers maintaining their BW advantage through the finishing phase.*

## Introduction

Historically, nitrogen (N) fertilizer has been used to increase forage production and subsequent stocking rate relative to the cost of application. In growing animals, weight gain is the primary determinant of N retention by cattle, and DDGS supplementation is very effective in increasing weight gain on high quality forages (*2007 Nebraska Beef Report*, pp. 10-11). Supplementing with DDGS and removing N fertilizer may improve N use efficiency by decreasing N inputs and capturing more N in the form of additional weight gain. Additionally, recent increases in energy and N costs may reduce the associated economic benefits of N fertilization, creating economic and environmental opportunities to enhance production through better management of N within grazing systems.

## Procedure

### *Treatments*

Predominantly British breed crossbred steers (726 ± 22 lb) were used in a randomized complete block design to evaluate supplementation and management strategies for steers grazing smooth bromegrass pastures. Data were collected in the summer during three consecutive years (2005, 2006 and 2007) to measure treatment effects on yearling steer performance, N use efficiency, subsequent feedlot performance, and impact on forage production and forage quality throughout the duration of the experiment. The treatments included yearling steers stocked at four AUM/acre on smooth bromegrass pastures fertilized with 80 lb N/acre (FERT); non-fertilized smooth bromegrass pastures stocked at 2.8 AUM/acre (CON); and non-fertilized smooth bromegrass pastures stocked at the same rate as the FERT with five lb DM of corn DDGS supplemented daily (SUPP).

### *Paddock Management*

Within each of three blocks, treatments were assigned randomly to one of three paddocks in the first year of the experiment. Paddocks maintained their treatment during subsequent years and paddock was the experimental unit. Paddocks were approximately 5.0 acres for FERT and SUPP and 7.2 acres for CON, and were grazed from late April through September. Previous studies at this site suggested equal animal performance could be obtained by reducing the stocking rate of nonfertilized pastures to 69% of the fertilized pastures. Each paddock was further divided equally into six strips to utilize a management-intensive rotational grazing system. The cattle were rotated through all six strips in each paddock for all five grazing cycles. The grazing period length was four days per strip in cycles 1 and 5, and six days per strip in cycles 2, 3 and 4. Urea was applied at 80 lb N/acre to the designated paddocks 14 to 21 days prior to the initiation of grazing.

In each of the three years of the experiment, 45 crossbred steers were blocked by weight and assigned randomly to the nine paddocks. The five steers per paddock were the tester animals. A variable stocking rate 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 between and within years based on the measured forage yield and visual observations.

### *Animal Management*

Steers were limit fed a common diet at approximately 1.75% BW for five days at the beginning and end of the trial. Limit-fed BWs were measured for three consecutive days to minimize the impact of variation in gut fill.

Following completion of the study, steers were finished on high concentrate diets containing high-moisture corn, dry-rolled corn, corn milling byproducts, alfalfa hay and supplement. The finishing diet was the same for all steers within a year but changed across the three years. On average, steers were fed for 109 days. Steers were not maintained in their original treatment groups within finishing pens. Therefore, effects of pasture treatment on finishing dry matter intake (DMI) and gain-to-feed ratio (G:F) are not available; only

ADG is available.

*Diet Sample Collection and Analysis*

Diet samples were collected at the mid-point of a grazing period with two ruminally fistulated steers. Pre-grazing standing crop dry matter amount was measured the day prior to each diet collection period using the drop disc method. During each sampling period, 50 disc measurements (2.8 ft$^2$) were taken at randomly selected locations and correlated to actual clipped data from quadrats (4.1 ft$^2$) placed immediately below every eighth disc location.

*Nitrogen Balance*

System N balance inputs included N from DDGS, fertilizer and atmospheric deposition. Outputs for the system N balance included N retention by the steers. Nitrogen excretion was calculated by subtracting N retention from total N consumption. The National Research Council (1996) model predicts protein deposition in the animal (N retention) from ADG. Nitrogen use efficiency of the system was calculated by dividing the system outputs (N retention) by the system inputs (N from DDGS and fertilizer).

*Statistical Analysis*

Data were analyzed using the MIXED procedures of SAS (SAS Inst., Inc., Cary, N.C.) as a randomized complete block design, with block considered to be a random effect. Model effects were year, treatment, year x treatment interaction, cycle and cycle x treatment interaction. Repeated measures were used to test the effects of time (cycle). Paddock was the experimental unit.

**Table 1. Main effects of dried distillers grains (DDGS) supplementation and N fertilization on diet sample characteristics and standing crop measurements of smooth bromegrass pastures grazed by yearling steers.**

| | Treatment[1] | | | | F-Test | |
|---|---|---|---|---|---|---|
| Item | CON | FERT | SUPP | SEM | TRT | YR |
| Total tract DMD[2] | 60.45 | 59.66 | 60.52 | 0.85 | 0.72 | < 0.01 |
| Protein | 15.21[a] | 17.25[b] | 16.19[a] | 0.49 | < 0.01 | < 0.01 |
| Standing crop lb/acre | 2051[a] | 2425[b] | 2208[a] | 102 | < 0.01 | < 0.01 |
| AUM/acre | 3.52d | 5.42[e] | 5.65[e] | 0.19 | < 0.01 | < 0.01 |

[1]Pastures were either non-fertilized (CON), fertilized with N at 80 lb/acre of N (FERT), or non-fertilized and steers were supplemented with 5 lb (DM) of DDGS (30.4% CP) daily for the entire grazing period (SUPP).
[2]Total tract DM digestibility (TTDMD) was determined by including five hay samples of varying qualities with known total tract *in vivo* digestibilities. The IVDMD values for these standards were regressed on their known digestibilities to develop an equation to calculate TTDMD within each *in vitro* run.
[a,b,c]Means in a row without a common superscript differ ($P < 0.05$).
[d,e]Means in a row without a common superscript differ ($P < 0.01$).

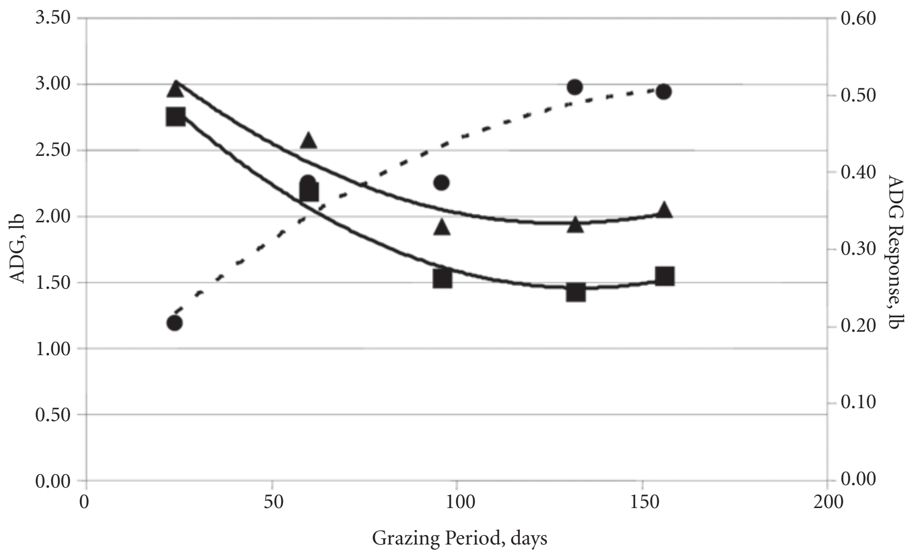


**Figure 1. Growth profile for steers grazing smooth bromegrass and supplemented with dried distillers grains. The quadratic decrease in cumulative ADG ($P < 0.01$) for both the supplemented (▲; $y = 0.0001x^2 – 0.0254x + 3.5743$; $R^2 = 0.94$) and nonsupplemented (■ ; $y = 0.0001x^2 – 0.03x + 3.4617$; $R^2 = 0.98$) cattle is expressed over the entire grazing period. The ADG response (-------●) of the supplemented cattle over the controls increases as grazing days increase. The quadratic ($y = -0.00005x^2 + 0.0046x + 0.1138$; $R^2 = 0.9235$) response is inversely related to diet quality.**

## Results

Fertilization had an effect on crude protein (CP) content ($P < 0.01$); however, the treatments did not affect dry matter digestibility of the forage diets (Table 1). CP content was higher for FERT ($P < 0.05$), but not different for SUPP compared with CON. Standing crop per acre for FERT was 18% greater than for CON ($P < 0.01$) and 10% greater than for SUPP ($P < 0.01$). Stocking rates were greater ($P < 0.01$) for FERT and SUPP (5.42 and 5.65 AUM/acre, respectively), compared with CON (3.52 AUM/acre). The fertilized paddocks had a 54% increase in stocking rate compared with the CON. Therefore, total gain (lb/acre; Table 2) was greater for FERT and SUPP compared with CON. Supplementation of DDGS increased stocking rate to the same level as FERT and increased steer performance. Clearly, this is an indication DDGS supplementation was an effective method to increase efficiency of land use for livestock production.

The SUPP steers gained more ($P < 0.01$) than CON and FERT steers (Table 2). Total gain per acre increased ($P < 0.01$) by 53% for FERT and more than doubled for SUPP (105%) compared with CON. This dramatic effect on gain/acre for the SUPP steers was due to the increase in both stocking rate and animal performance. The large increase in gain/acre for the FERT steers was solely due to the increase in stocking rate because animal performance

(Continued on next page)

**Table 2. Main effects of grazing management and supplementation strategies on pasture performance for steers grazing smooth bromegrass.**

| | Treatment[1] | | | | F-test | |
|---|---|---|---|---|---|---|
| Item | CON | FERT | SUPP | SEM | TRT | YR |
| Head days[2] | 834 | 897 | 884 | — | — | — |
| Area, acre | 7.16 | 4.96 | 4.96 | — | — | — |
| Initial BW, lb[3] | 726 | 724 | 726 | 7 | 0.95 | < 0.01 |
| Final BW, lb[3] | 968[a] | 961[a] | 1049[b] | 9 | < 0.01 | < 0.01 |
| BW gain, lb | 242[a] | 238[a] | 323[b] | 7 | < 0.01 | < 0.01 |
| Gain per acre, lb[4] | 176[a] | 269[b] | 360[c] | 7 | < 0.01 | < 0.01 |
| ADG, lb | 1.50[a] | 1.47[a] | 2.02[b] | 0.04 | < 0.01 | < 0.01 |

[1]Pastures were either non-fertilized (CON), fertilized with N at 80 lb/acre of N (FERT), or non-fertilized and steers were supplemented with 5 lb (DM) of DDGS (30.4% CP) daily for the grazing period (SUPP).
[2]Head 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.
[3]Shrunk weight; steers were limit fed 5 days immediately prior to measuring initial and final weights.
[4]Calculated by multiplying ADG by the total number of head days, then dividing by the number of acres.
[a,b,c]Means in a row without a common superscript differ ($P < 0.01$).

**Table 3. Main effects of grazing management and supplementation strategies on feedlot performance and carcass characteristics for steers grazing smooth bromegrass.**

| | Treatment[1] | | | | F-test | |
|---|---|---|---|---|---|---|
| Item | CON | FERT | SUPP | SEM | TRT | YR |
| Days | 109 | 109 | 109 | — | — | — |
| Initial BW, lb[3] | 1005[a] | 1003[a] | 1087[b] | 3 | < 0.01 | < 0.01 |
| Final BW, lb[4] | 1426[a] | 1426[a] | 1516[b] | 15 | < 0.01 | < 0.01 |
| ADG, lb | 3.85 | 3.89 | 3.93 | 0.1 | 0.88 | < 0.01 |
| HCW, lb | 904[a] | 906[a] | 961[b] | 9 | < 0.01 | < 0.01 |
| Fat, in | 0.49 | 0.49 | 0.57 | 0.07 | 0.12 | 0.06 |
| Marbling score[5] | 545[c] | 530[c] | 603[d] | 18 | < 0.01 | 0.18 |

[1]Pastures were either non-fertilized (CON), fertilized with N at 80 lb/acre of N (FERT), or non-fertilized and steers were supplemented with 5 lb (DM) of DDGS (30.4% CP) daily for the grazing period (SUPP).
[2]Individual intakes not available during the feedlot phase.
[3]Limit-fed weights were the average of two consecutive days following a 5-day limit-fed period.
[4]Carcass adjusted final weight, calculated from HCW, adjusted by a common dressing percentage of 63.5%.
[5]Where 400 = Slight 0; 500 = Small 0.
[a,b]Means without a common superscript differ ($P < 0.01$).
[c,d]Means without a common superscript differ ($P < 0.05$).

**Table 4. Main effects of pasture nitrogen (N) balance for grazing management and supplementation strategies of smooth bromegrass pastures grazed by yearling steers.**

| | Treatment[2] | | | | *P*-value | | |
|---|---|---|---|---|---|---|---|
| Item[1] | CON | FERT | SUPP | SEM | INT | YR | TRT |
| N inputs | | | | | | | |
| N from DDGS | 0 | 0 | 43 | — | — | — | — |
| N fertilizer | 0 | 80 | 0 | — | — | — | — |
| N atmospheric deposition[3] | 5.8 | 5.8 | 5.8 | — | — | — | — |
| Total N inputs | 5.8 | 85.80 | 48.8 | 1.4 | < 0.01 | < 0.01 | < 0.01 |
| N consumption | | | | | | | |
| N from DDGS | 0 | 0 | 43.6 | — | — | — | — |
| N from forage | 43.2 | 74.8 | 69.1 | 2.1 | 0.06 | < 0.01 | 0.14 |
| Total N consumption | 43.2 | 74.8 | 112.7 | 2.1 | < 0.01 | < 0.01 | < 0.01 |
| N retention[4] | 4.7[a] | 7.2[b] | 9.3[c] | 0.15 | 0.20 | < 0.01 | < 0.01 |
| N excretion | 38.5 | 67.6 | 103.4 | 2.0 | < 0.01 | < 0.01 | < 0.01 |
| N balance (surplus)[5] | 1.1[a] | 78.8[b] | 40.10[c] | 0.15 | < 0.01 | < 0.01 | < 0.01 |
| Apparent N recovery rate, %[6] | 81.18[a] | 8.33[b] | 19.12[c] | 1.65 | < 0.01 | < 0.01 | < 0.01 |
| N use efficiency, %[7] | — | 8.93[a] | 21.77[b] | 0.26 | < 0.01 | < 0.01 | < 0.01 |

[1]Items are expressed as total lb of N per acre for the entire grazing period, unless otherwise noted.
[2]Pastures were either non-fertilized (CON), fertilized with dry urea at 80 lb/acre of N (FERT), or non-fertilized and steers were supplemented with 5 lb (DM) of DDGS (30.4% CP) daily for the entire gazing period (SUPP).
[3]Data from the National Atmospheric Deposition Program. 2008. Available at *http://nadp.sws.uiuc.edu/isopleths/maps2006/ndep.gif*. Accessed on Jan. 7, 2008.
[4]N retention calculated from NRC (1996) equations.
[5]Difference between total N inputs and N retention.
[6]Calculated by dividing N retention by total N inputs, multiplied by 100.
[7]Calculated by dividing system outputs (N retention) by system inputs (N from DDGS and N fertilizer), multiplied by 100.
[a,b,c]Means within a row without a common superscript differ ($P < 0.01$).

between the CON and FERT steers was similar and stocking rate was increased by 54%. Average daily gain, measured from interim weights, decreased quadratically ($P < 0.01$) over the entire grazing season for supplemented and non-supplemented steers (Figure 1). The response, or difference between the supplemented and non-supplemented steers, increased quadratically ($P < 0.01$) over the grazing period, suggesting that the performance advantage increased with decreasing forage quality and then began to level off once re-growth occurred toward the end of the grazing period.

Finishing performance from steers in years 1 and 2 is shown in Table 3. Daily gain was similar among treatments, indicating that no compensatory response from the grazing phase was carried over into the finishing phase. Therefore, the weight advantage of SUPP from the grazing phase was maintained throughout the feedlot.

System-based N use efficiency (N retention per acre ÷ N input of fertilizer and DDGS per acre × 100) improved ($P < 0.01$; Table 4) by 139% for SUPP (21.37%) compared to FERT (8.93%). This ultimately indicates that N from DDGS is better converted into saleable product than N from fertilizer in these management and pasture conditions.

In combination with intensively managed pastures and better urine distribution, DDGS supplementation has the potential to increase N content and cycling of N in the pasture. Nitrogen use efficiency was improved by decreasing N inputs and capturing more N in the form of additional weight gain and in the cycling of N in the pasture. Dried distillers grains can be used as a substitute for forage and N fertilizer by improving performance and N use efficiency in smooth bromegrass pastures in eastern Nebraska.

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