Comparison of 3 tall fescue-based stocker systems

N. J. Bailey and R. L. Kallenbach

Division of Plant Sciences, University of Missouri, Columbia 65211

ABSTRACT: A 2-yr production study was conducted to evaluate 3 systems of growing stocker calves under rotational stocking. One group of steers was stocked on pasture from early April to mid August (spring-stocked steers = SSS), and another group of steers was stocked from early July to late October (fall-stocked steers = FSS). Steers were stratified by BW (n = 72, BW = 229 ± 11 kg for SSS; n = 72, BW = 248 ± 18 kg for FSS) and randomly assigned to 1 of 3 treatments. The 3 treatments were 1) rotationally stocked only (control; CON), steers rotated to a new paddock as forage availability dropped below acceptable levels in the occupied paddock; 2) rotationally stocked with distillers grains (DIST); this was the same as CON except steers were supplemented with varying amounts of distillers dried grains with solubles (DDGS) based on forage nutritive value; and 3) rotationally stocked with round-bale silage (SIL); excess forage in spring was harvested and stored as round-bale silage and fed back as needed. Total BW gain/ha over the entire grazing season did not differ between DIST and SIL (P = 0.09) steers, but both were greater than CON (P < 0.01). Total BW gain/ha for DIST, SIL, and CON was 459 (SEM = 11.5), 402 (SEM = 31.0), and 276 (SEM = 26.2) kg, respectively. For ADG, there was a group × year (P < 0.01) and group × treatment (P = 0.02) interaction. Steer ADG for SSS did not differ between SIL and DIST (P = 0.51), but was greater than the CON (P = 0.01). The ADG for SSS was 0.79 (SEM = 0.04), 0.81 (SEM = 0.05), and 0.62 (SEM = 0.05) kg for DIST, SIL, and CON, respectively. For the FSS, ADG for all 3 treatments was different (P = 0.02). The FSS ADG was 0.72 (SEM = 0.03), 0.53 (SEM = 0.04), and 0.29 (SEM = 0.04) kg for DIST, SIL, and CON, respectively. The only treatment with equivalent (P = 0.07) ADG between early and late-stocked steers (SSS vs. FSS) was DIST. Adjusting the amount of DDGS supplemented to steers based on forage nutritive value resulted in consistent BW gains throughout the grazing study, whereas steers in the SIL and CON treatments gained less BW during the latter portion of the season. Controlling forage maturity by removal in the SIL treatment resulted in total BW gains/ha that were not different than the DIST treatment.

Key words: distillers grain, rotational grazing, silage, stocker cattle, tall fescue

INTRODUCTION

Systems-scale research involving forage management for stocker cattle is largely untested (Allen et al., 2000). One common practice for this segment of the industry is to offer a feed supplement to improve animal BW gains (Paterson et al., 1994; Kunkle et al., 2000). Studies regarding supplementation of energy to calves on pasture generally show a daily BW gain increase, but BW gains are variable and unpredictable (Bowman and Sowell, 1997). Because many of these studies used constant preset levels of supplementation (e.g., 0.5, 1.0, 2.0 kg-steer⁻¹·d⁻¹), the variation in ADG may be attributed to fluctuations in forage nutritive value or availability during the study. No studies could be found that adjusted the amount of supplementation to stocker calves based on fluctuating forage nutritive value over the growing season.

Morris et al. (2005) reported that supplementing low and high nutritive value forage with distillers dried grains with solubles (DDGS) increased daily BW gains of heifers. In addition, DDGS should not have a negative effect on forage digestion as other high energy supplements may (MacDonald and Klopfenstein, 2004). Rather, DDGS should merely replace forage that would have otherwise been consumed (MacDonald and Klopfenstein, 2004). This attribute is especially beneficial if cattle are stocked on cool-season grass pasture through
the summer months when nutritive value is typically poor.

We hypothesized that BW gains of stocker steers would be similar between a system where DDGS was fed based on forage nutritive value and a system where forage maturity level was controlled by removal as round-bale silage, and that both would be greater than a system with rotation of animals only. The objective of this study was to determine if feeding DDGS to stocker steers in an attempt to maintain ADG of 0.9 kg (based on the nutritive value of available forage) would be comparable with either of 2 alternative systems where supplement was excluded or forage was managed differently or both.

MATERIALS AND METHODS

The University of Missouri Animal Care and Use Committee reviewed and approved all animal management procedures.

A 2-yr grazing study was conducted at the University of Missouri South Farm located near Columbia, MO, during 2006 (yr 1) and 2007 (yr 2). The soils at this location were classified as Armstrong loam (fine, smectitic, mesic Aquertic Hapludalf), 5 to 9% slope, Mexico silt loam (fine, smectitic, mesic Aeric Vertic Epiaqualf), 1 to 3% slope, and Vanmeter clay loam (fine, illitic, mesic Oxyaqueptic Eutrudalf) 5 to 14% slope. In preparation for the study, the soils were tested for pH, phosphorus, and potassium. Fertilizer was applied to pastures as needed based on the recommendations of University of Missouri Soil Testing Laboratory (Brown and Rodriguez, 1983) before yr 1. Phosphorus and potassium were applied on February 23, 2006, to pastures determined deficient from soil analyses. Phosphorus was increased to a minimum of 33 kg·ha−1 Bray 1, and potassium was increased to a minimum of 225 kg·ha−1. Correction of soil pH was not necessary; the mean soil test pH value was 6.71 ± 0.22.

Study pastures were approximately 50% tall fescue [**Lolium arundinaceum** (Schreb.) Darbysh. = *Schedonorus arundinaceus* (Schreb.) Dumort.] and 30% red *Trifolium pratense* L.) and white clover (*Trifolium repens* L.), based on visual estimation. The remaining 20% was a mixture of Kentucky bluegrass (*Poa pratensis* L.), orchardgrass (*Dactylis glomerata* L.), and various dicotyledonous forbs. All pastures were broadcast seeded with 6 kg·ha−1 medium red clover and 0.5 kg·ha−1 Durana white clover on February 22, 2006. Pastures were typical of the region and did not vary in botanical composition enough to warrant blocking.

TREATMENTS AND EXPERIMENTAL DESIGN

Treatments were 1) rotationally stocked only (control: CON), steers rotated to a new paddock as forage in the occupied paddock was grazed to about a 7.5-cm residual height; 2) rotationally stocked with DDGS (DIST), identical to CON except steers were supplemented with DDGS in an attempt to maintain 0.9 kg·d−1 of BW gain based on weekly forage nutritive value analyses; and 3) rotationally stocked with round-bale silage (SIL), with excess spring forage harvested and stored as round-bale silage, then fed back to the steers as available forage became limiting during the summer months. Two groups of steers were stocked in each system each year: spring-stocked steers (SSS) and fall-stocked steers (FSS).

Forage Characterization and Paddock Management

Each tall fescue-based system was divided into six 0.27-ha paddocks (Bertelsen et al., 1993). The paddocks were rotationally stocked starting in spring when the tall fescue reached approximately 10 cm in height. A common alleyway for each system provided access to water, mineral, ionophore, and facilitated rotation of animals.

Because stocking rate has a profound influence on animal performance (Sollenberger et al., 2005), all 3 treatments were stocked at the same rate. Pastures were initially stocked at 567 kg·ha−1 of BW. Based on estimated forage intake and anticipated forage production and utilization, this stocking rate was estimated to be suitable for this environment and site (Gerrish, 2000). Gerrish (2000) indicated that available NE_{m}/ha was greatest with initial stocking rates at 336 kg·ha−1 of BW, and least at 1,344 kg·ha−1 of BW. It was expected that low forage nutritive value and poor steer ADG would occur in the CON treatment during the summer months due to excess springtime forage production and accumulation. The same forage accumulation and decline in forage nutritive value for the DIST treatment was also expected, but the anticipated decline in steer ADG was to be mitigated by feeding DDGS to the steers. Accumulated forage of poor nutritive value was grazed by the calves in the CON and DIST treatments.

Forage made into round-bale silage in the SIL treatment was cut on May 2, May 12, and June 9, 2006, and May 16, 2007. Although not preplanned, round-bale silage was produced from within every paddock of the SIL treatment. Some of the paddocks were accessed by steers before round-bale silage production, and some paddocks were accessed after round-bale silage production. Residual height of the forage was approximately 10 cm. Leaving that amount of residual leaf area was expected to slow growth rates little because more than 50% of tall fescue leaves are generally below this height (Wolf et al., 1979). The tall fescue was in the late vegetative to boot stage at cutting and was baled when forage reached 500 to 600 g·kg−1 water content. Bales were removed from the field and wrapped within 6 h with 4 layers of 25.4-μm-thick plastic (50% overlap). No other paddocks in any of the systems were moved except for 2 paddocks in 1 replication of DIST treatment in yr 2 due to excessive ragweed (*Ambrosia* spp.) pressure.
Available forage was assessed weekly by taking 50 rising plate meter (RPM) readings within each paddock (Earle and McGowan, 1979). The RPM measurements were calibrated every 21 d by collecting and weighing forage cut to a 2-cm height from 10 strips, each 0.82 × 4.6 m in dimension. The strips were cut with a flail-type harvester from the most recently stocked and next-to-be-stocked paddocks in each replication. The forage collected from the strips was subsampled (300 ± 50 g of fresh mass) and placed in a forced-air oven at 50°C until weight stabilization to determine water content. The DM value of the collected subsamples was used to calculate DM for each strip, then for each paddock on a kilogram per hectare basis. The values of the most recently stocked and next-to-be-stocked paddocks along with its corresponding RPM measurements were then used in a multiple regression equation (R² = 0.93) to estimate forage for each paddock within the replication. The weekly difference in forage DM divided by number of days between sampling events was considered the growth rate for unoccupied paddocks. The regression equation used to predict forage DM amounts (including pre- and post-silage removal) was

$$\text{DM} = (\text{YR}^2 \times -29.1) + (\sqrt{\text{RPM}} \times 1.085) + (\text{DOY}^2 \times 0.07389) + (\text{DOY}^3 \times -0.00019764), \quad [1]$$

where YR was year and DOY was ordinal day of the year.

After pregrazing and postgrazing forage yields were calculated, growth rate for each stocking period was determined by averaging the growth rates of the unoccupied paddocks within each treatment. Forage growth while animals were grazing an individual paddock was then added to pregrazing yield to accurately estimate the amount of forage available for grazing. Growth rate of forage was greater than consumption early in the season, which led to a long stocking period within some individual paddocks. The animals were not removed from an individual paddock until forage was grazed to an average canopy height of about 7.5 cm (visual estimation excluded refused forage, especially around dung pats and suspected urine patches).

Forage samples were hand collected on a weekly basis for nutritive value analyses by cutting forage to a 2-cm height from the paddock in each treatment where calves were expected to be stocked for the majority of the coming week. The samples were collected regardless of apparent forage quality or pattern of animal grazing, although it was understood that nutritive value declined with canopy height and cattle would be reluctant to graze stems of mature tall fescue (Krysl and Hess, 1993; Mertens, 2007).

The forage samples were dried, ground, and passed through a 1-mm screen for tissue analysis of CP and in vitro true digestibility (IVTD) using near-infrared reflectance (NIR) spectroscopy. The NIR spectrophotometer was a Pacific Scientific 6250 scanning monochromator (NIRSystems, Silver Spring, MD) operating with software developed by Infrasoft International (Port Matilda, PA). The spectrophotometer was calibrated for CP and IVTD by regressing chemically derived data against spectral data using modified partial least squares regression (Westerhaus et al., 2004; Table 1). The calibration for N was determined by thermal conductivity detection with a Leco FP-428 nitrogen analyzer (Leco Corp., St. Joseph, MI). Samples analyzed for IVTD were digested 48 h in vitro and then washed with NDF solution (Spanghero et al., 2003). The rumen fluid used for the digestion was collected from a cannulated cow fed a forage-based diet.

Forage nutritive value samples for the DIST treatment were collected as all others were each week, but a portion of these samples were immediately analyzed for ADF and NDF to adjust the amount of DDGS fed in an attempt to maintain the recommended (NRC, 1996) caloric intake for the calves to gain 0.9 kg·d⁻¹. Acid detergent fiber and NDF samples for DIST were determined with an Ankom 200 Fiber Analyzer (Ankom Technology, Fairport, NY). The equations used to calculate NEₘ and NEₙ of available forage were (modified equations from Belyea and Ricketts, 1993)

$$\text{NE}_m \text{ Mcal·kg}^{-1} = 2.205 \times [0.996 - (0.0112 \times \%ADF)]; \quad [2]$$

$$\text{NE}_n \text{ Mcal·kg}^{-1} = 2.205 \times [0.78 \times (\text{NE}_m \times 2.2) - 0.186]. \quad [3]$$

Table 1. Calibration statistics for near-infrared spectrophotometric determination of CP and in vitro true digestibility (IVTD) content of rotationally stocked tall fescue-based pastures

<table>
<thead>
<tr>
<th>Constituent, g·kg⁻¹ DM</th>
<th>n</th>
<th>R²</th>
<th>Mean</th>
<th>SEC¹</th>
<th>SECV²</th>
<th>1 − VR³</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP</td>
<td>72</td>
<td>0.99</td>
<td>124</td>
<td>0.35</td>
<td>0.69</td>
<td>0.97</td>
</tr>
<tr>
<td>IVTD</td>
<td>71</td>
<td>0.99</td>
<td>751</td>
<td>1.00</td>
<td>1.93</td>
<td>0.95</td>
</tr>
</tbody>
</table>

¹SEC = SE of calibration calculated in modified partial least squares regression.
²SECV = SE of cross-validation calculated in modified partial least squares regression.
³1 − VR = 1 minus the variance ratio (calculated in cross-validation in modified partial least squares regression).
Once the amount to supplement was determined (described below), the adjusted amount was started the following Monday. It was assumed at the beginning of the study that each batch of DDGS would vary in nutrient concentrations (Spiehs et al., 2002). Therefore, to accurately compensate for the fluctuation of tall fescue nutritive value and to attempt to maintain steer ADG at 0.9 kg, the DDGS was sampled and analyzed by batch. Analysis of the DDGS is given in Table 2.

### Steer Management

Calves were purchased from a local sale barn 3 to 5 wk in advance of each turnout to ensure procurement of adequate study animals. Upon arrival, the calves were placed in a drylot and given a typical receiving diet. Within 2 wk of arrival, calves were castrated if necessary, vaccinated with 7-way blackleg with hemophilus (Ultrabac 7/Somubac, Pfizer, Exton, PA) and bovine rhinotracheitis-virus diarrhea-parainfluenza-3-respiratory syncytial virus modified live virus vaccine with Mannheimia hemolytica toxoid (Pyramid 4+ Prespense SQ, Fort Dodge Animal Health, Fort Dodge, IA), and given an ear identification tag. Approximately 3 wk after the initial administration of vaccines, the steers were treated with the anthelmintic [moxidectin (Cydec tin, Pfizer, New York, NY) or ivermectin (Ivomec, Merial, Duluth, GA)], tagged with pyrethroid and organophosphate insecticide-impregnated ear tags, implanted with zeranol (Ralgro, Intervet/Schering-Plough Animal Health, Kenilworth, NJ), and had a second round of the initial vaccines administered to ensure proper immunity. Any animals during this period displaying symptoms of respiratory ailments were treated with tilmicosin (Micotil, Elanco, Greenfield, IN) or florfenicol (Nuflor, Intervet/Schering-Plough Animal Health).

Grazing began April 11 and April 13 for SSS in yr 1 and 2, respectively. These steers were removed from pasture August 8 for yr 1 and August 13 for yr 2. Fall-stocked steers began grazing study pastures July 5 for yr 1 and July 6 for yr 2. These steers were removed from pastures (unless otherwise specified) November 2 for yr 1 and October 29 for yr 2. Before grazing began each year, steers were deprived of feed for 15 ± 1 h, weighed (239.0 ± 18.0 kg), stratified by BW into groups of 4 steers each, and groups then randomly assigned to 1 of the 3 treatments. Each treatment had 3 replications for a total of 36 (3 treatments × 3 replications × 4 steers) SSS and 36 FSS each year.

Upon removal from pasture, steers were again deprived of feed for 15 ± 1 h and weighed. The second group for yr 2 was removed from pasture October 29, 2007, except for 1 replication of the CON, which was removed from study on October 15, 2007, due to inadequate available forage. Over the course of this research, 4 steers were removed prematurely from study for reasons unrelated to the study treatments. The removed steers were immediately replaced by extra steers held for this purpose in an adjacent pasture. Replacement steers had no data collected on them other than initial BW.

Neutral detergent fiber intake for steers in the DIST treatment was assumed to be 12.5 g·kg⁻¹ of BW·d⁻¹ (Mertens, 1994). Based on forage NDF values and megacalories per kilogram of NE of forage DM during the course of the grazing period, available forage always met maintenance requirement for animals. According to the NRC (1996), a 250- to 350-kg steer requires 4.84 to 6.23 Mcal·d⁻¹ for NEm. Therefore, all DDGS supplemented was for BW gain. Each replication was supplemented its own rate and was started when 2 consecutive weeks indicated that 1 Mcal·steer⁻¹·d⁻¹ of NEg was needed to maintain steer ADG at 0.9 kg.

For the SSS, DDGS supplementation started May 10, 2006, and May 14, 2007, for all 3 replications and ended when steers were removed from pasture in August. Fall-stocked steers required supplement the entire time on pasture. Distillers dried grains with solubles were supplemented on alternate days. Any steers reluctant to approach the troughs were directed to them until they were trained to approach under their own volition. Once trained, all steers consumed DDGS freely at every feeding. Although the amount fed varied by week based on forage nutritive value, for the period supple-

### Table 2. Nutrient composition (DM basis) of distillers dried grains with solubles (DDGS) fed to steers¹

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th><strong>Mean</strong>²</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP, g·kg⁻¹</td>
<td>5</td>
<td>286.9</td>
<td>27.1</td>
<td>240.9</td>
<td>312.9</td>
</tr>
<tr>
<td>ADF, g·kg⁻¹</td>
<td>5</td>
<td>91.8</td>
<td>9.2</td>
<td>76.3</td>
<td>100.0</td>
</tr>
<tr>
<td>NDF, g·kg⁻¹</td>
<td>3</td>
<td>330.2</td>
<td>15.3</td>
<td>319.0</td>
<td>347.7</td>
</tr>
<tr>
<td>TDN, g·kg⁻¹</td>
<td>5</td>
<td>888.2</td>
<td>23.2</td>
<td>869.4</td>
<td>928.6</td>
</tr>
<tr>
<td>Crude fat, g·kg⁻¹</td>
<td>5</td>
<td>103.3</td>
<td>4.7</td>
<td>98.0</td>
<td>110.0</td>
</tr>
<tr>
<td>N, g·kg⁻¹</td>
<td>5</td>
<td>45.9</td>
<td>4.4</td>
<td>38.5</td>
<td>50.1</td>
</tr>
<tr>
<td>Ca, g·kg⁻¹</td>
<td>5</td>
<td>0.3</td>
<td>0.1</td>
<td>0.2</td>
<td>0.4</td>
</tr>
<tr>
<td>P, g·kg⁻¹</td>
<td>5</td>
<td>8.1</td>
<td>0.6</td>
<td>7.3</td>
<td>8.7</td>
</tr>
<tr>
<td>NEg, Mcal·kg⁻¹</td>
<td>5</td>
<td>1.52</td>
<td>0.04</td>
<td>1.48</td>
<td>1.61</td>
</tr>
<tr>
<td>NEem, Mcal·kg⁻¹</td>
<td>5</td>
<td>2.21</td>
<td>0.07</td>
<td>2.14</td>
<td>2.32</td>
</tr>
<tr>
<td>DE, Mcal·kg⁻¹</td>
<td>5</td>
<td>2.54</td>
<td>0.75</td>
<td>2.14</td>
<td>3.88</td>
</tr>
</tbody>
</table>

¹The amount of DDGS fed to steers was dictated by nutritive value of available forage.
²Samples averaged 920 ± 8.4 g·kg⁻¹ DM.
ment was provided, the average amount fed was 1.2 kg·steer\(^{-1}\)·d\(^{-1}\) for SSS and 1.7 kg·steer\(^{-1}\)·d\(^{-1}\) for FSS. The specific amounts fed are provided in Figure 1. As the steers grew and their NE\(_g\) requirements increased, the amount of DDGS supplemented was adjusted accordingly as the animals met the BW increments (Table 9-1, NRC, 1996).

Round-bale silage was fed back to the steers in the alley of the SIL treatment using modified sheep hay feeders. The feeder allowed the silage to remain off the ground while being consumed by steers. Additional silage was fed to the steers as previously fed silage disappeared. The first feeding of silage occurred on July 7, 2006, and July 7, 2007. The initiation of silage-feeding coincided with the placement of FSS on pasture due to limited forage availability in late summer. Available forage in the SIL treatment was approximately 3,000 kg·ha\(^{-1}\) (Figure 2) when silage was first fed back to the steers. In vitro true digestibility, CP, and DM were determined for the silage at every feeding. The final silage feeding dates (using treatment-produced silage) were August 25, 2006, and August 31, 2007. Due to the forage shortage in year two, 245 ± 143 kg of round-bale silage produced from outside the treatment pastures was fed to steers in the SIL treatment from October 12 to October 19, 2007. The silage was produced from adjacent pastures of similar composition stored for this specific purpose.

A commercial free-choice mineral (MFA Gold Star, MFA Inc., Columbia, MO) was offered to steers in all treatments. The manufacturer guaranteed analysis of the mineral (DM basis) was 150 to 170 g·kg\(^{-1}\) of Ca, 75 g·kg\(^{-1}\) of P, 150 to 170 g·kg\(^{-1}\) of NaCl, 15 g·kg\(^{-1}\) of Mg, 1 g·kg\(^{-1}\) of K, 1,330 mg·kg\(^{-1}\) of Cu, 26.6 mg·kg\(^{-1}\) of Se, 6,700 mg·kg\(^{-1}\) of Zn, 4,500 mg·kg\(^{-1}\) of Mn, 882,000 IU·kg\(^{-1}\) of vitamin A, 1,852 IU·kg\(^{-1}\) of vitamin D, and 5.3 IU·kg\(^{-1}\) of vitamin E. The ionophore lasalocid (Bovatec, Alpharma, Bridgewater, NJ) was included at 1.6 g·steer\(^{-1}\)·d\(^{-1}\), and expected mineral mix intake was 113 g·steer\(^{-1}\)·d\(^{-1}\).

**Statistical Analyses**

The experiment was a completely randomized design (Steel and Torrie, 1980) with 4 steers in each experimental unit (pasture). Each treatment was replicated 3 times and repeated for 2 yr. The model was a mixed model with replication and year as random variables. The fixed variables were forage system (CON, SIL, or DIST) and group. The MIXED procedure (SAS Inst. Inc., Cary, NC) was used to test all main effects and all possible interactions. Repeated measures procedures assuming first-order autoregressive correlation were used to test effects of treatments for the amount of forage produced. Orthogonal contrasts were used to compare ADG, total animal BW gain per hectare, and total forage per hectare produced. Forage DM produced for each system was predicted using stepwise regression (PROC REG of SAS) to determine variables to include in the model, then using the selected variables as described previously and shown in Eq. [1]. Significance level for variables to enter and stay in the model was set at 0.01.
RESULTS AND DISCUSSION

Pasture Growth and Nutritive Value

There was neither a year ($P > 0.14$) nor a treatment × year ($P > 0.33$) effect for total forage production or IVTD. In addition, there was no interaction of treatment and year ($P > 0.68$) for available forage or CP. Therefore, data were combined over years for these measures. Total forage produced did not differ between treatments ($P = 0.44$). Total forage produced was 6,420 (SEM = 203), 7,264 (SEM = 365), and 6,240 (SEM = 170) kg·ha$^{-1}$ for CON, DIST, and SIL treatments, respectively. Forage harvested for round-bale silage in the SIL treatment was a portion of the total annual forage production. Available forage did not differ across treatments until forage harvest in May for the SIL treatment (Figure 2). Further, available forage (Figure 2) and IVTD (Figure 3) did not differ ($P > 0.12$) between the CON and DIST treatments. In vitro true digestibility of available forage was greater ($P < 0.01$) for the SIL treatment compared with the CON and DIST after mid May (after forage harvested as round-bale silage).

At the inception of the study, it was postulated that the SIL treatment would produce more forage than the DIST and CON treatments. The rationale was the paddocks not grazed until later in the grazing season in the DIST and CON treatments would have a zero net gain in forage DM once the ceiling yield was reached due to leaf senescence and turnover. Net primary production climaxes when the canopy intercepts all incident light (Parsons and Chapman, 2000). This occurred in some of the paddocks in the CON and DIST treatments that were not grazed until later in the season. Conversely, paddocks in the SIL treatment generally were less than the DM required to capture all incident light (Parsons and Chapman, 2000).

Although residual leaf area after silage removal in the SIL treatment should have generated fast forage regrowth, and net primary production of DM climaxed in some paddocks of the CON and DIST treatments, total forage produced in the SIL treatment was not greater ($P = 0.44$) than the DIST and CON treatments. This may partially be attributable to below average precipitation and removal of fertilizer nutrients as round-bale silage. Dry weather conditions precluded adequate regrowth rates in the SIL treatment because precipitation (both years) was below average during critical periods of the growing season. Net primary production likely would have been greater if normal precipitation patterns would have prevailed.

Much of the forage produced in the CON and DIST treatments was not utilized in some of the paddocks due to leaf turnover and DM loss. In an attempt to maximize forage regrowth nutritive value, steers were held in individual paddocks long enough to graze forage to acceptable residual height. Doing so resulted in some of the paddocks within the CON and DIST treatments to remain ungrazed for periods exceeding 57 d. The lifespan of a tall fescue leaf is approximately 57 d (Par-
sons and Chapman, 2000), with a photosynthetically active period of about 42 d during spring and summer (Wolf et al., 1979). This resulted in leaf turnover and loss of DM production. The amount of forage lost to turnover was not measured in this study. However, the majority of DM produced may be lost to leaf turnover in ungrazed paddocks (Parsons and Chapman, 2000), and 400 g·kg⁻¹ may be lost if stocking density is low (Parsons and Leafe, 1981). The DM loss in the CON and DIST treatments may have approached DM losses in the SIL treatment due to the harvesting process and storage.

Round-bale silage produced in the SIL treatment averaged 1,909 ± 582 kg·ha⁻¹. Total silage fed back in the SIL treatment was 1,889 ± 387 kg. Dry matter loss associated with individually wrapped round-bale silage ranges from 30 to 400 g·kg⁻¹, with expected losses of about 80 g·kg⁻¹ under good management (Muck and Kung, 2007).

### Steer BW Gain

Average daily gain will be used to discuss treatment differences in detail. However, total BW gain/ha was 459 (SEM = 11.5), 402 (SEM = 31.0), and 276 (SEM = 26.2) kg for DIST, SIL, and CON, respectively. Total BW gain/ha for DIST and SIL were not different \( (P = 0.09) \), and both were greater than the CON \( (P < 0.01) \).

There was a group × treatment \( (P = 0.02) \) and group × year \( (P < 0.01) \) interaction for ADG, but no year effect \( (P > 0.91) \) or year × treatment interaction \( (P > 0.14) \); therefore, data were combined over year, but analyzed by group. For the SSS, steer ADG in the DIST and SIL treatments were not different \( (P = 0.51) \), but steers in the CON treatment gained less BW \( (P = 0.01; \text{Table 3}) \). All treatments had adequate available forage \( (>3,000 \text{ kg·ha}^{-1}) \) when the SSS were removed from pasture (Figure 2), but by this time the forage nutritive value in the CON and DIST treatment had declined. Crude protein was approximately 90 g·kg⁻¹, and IVTD had declined to approximately 650 g·kg⁻¹ (Figures 3 and 4). In contrast, CP and IVTD values in the SIL treatment remained at about 140 and 800 g·kg⁻¹, respectively. Due to the greater nutritive value of the available forage in the SIL treatment, these steers would have been expected to gain more BW than the steers in the CON treatment. Based on weekly ADF and NDF analyses (data not shown) from the DIST treatment, the expected ADG of the CON steers was about 0.4 kg from June to removal from pasture in August (Figure 1). This value was less than the target ADG of 0.9 kg for the supplemented steers in the DIST treatment, and less than the anticipated steer ADG in the SIL treatment based on greater forage nutritive values.

For FSS, ADG was different for all 3 treatments \( (P = 0.02; \text{Table 3}) \). By this time, the amount and nutritive value of available forage had declined in the CON treat-
ment, which negatively influenced steer ADG. Forage nutritive value in the SIL treatment remained relatively good, but available forage declined to quantities that may have reduced intake (Minson, 1990). Steers in the DIST treatment had adequate amounts of forage compared with the SIL treatment, and the poor nutritive value of the available forage was alleviated by supplementation of DDGS. Given the characteristics of each pasture system and the fact that steers in the DIST treatment were supplemented with energy and protein, it was not surprising that ADG varied across the 3 treatments for FSS.

Average daily gains for SSS were greater \( (P < 0.01) \) than FSS in the CON and SIL treatments (Table 3).

![Figure 4. Crude protein of available forage of the paddock steers that were likely to be stocked in the week after sample collection. All paddocks were tall-fescue-based and rotationally stocked. Both years were combined, and bars equal 2·SEM to give 95% confidence intervals. Non-overlapping bars for any particular sampling period indicate significance at the 0.05 level. Contrast \( P \)-value for rotationally stocked only (control; CON) vs. rotationally stocked with distillers dried grains with solubles (distillers; DIST) for the entire study period was 0.15. Contrast \( P \)-value for rotationally stocked with round-bale silage (silage; SIL) vs. others for the entire study period was <0.01.](image)

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment (^1)</th>
<th>Contrast, (^2) ( P )-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CON</td>
<td>DIST</td>
</tr>
<tr>
<td>SSS(^3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADG, kg</td>
<td>0.62</td>
<td>0.79</td>
</tr>
<tr>
<td>n</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>SEM</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>FSS(^4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADG, kg</td>
<td>0.29</td>
<td>0.72</td>
</tr>
<tr>
<td>n</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>SEM</td>
<td>0.04</td>
<td>0.03</td>
</tr>
<tr>
<td>Contrast, (^5) ( P )-value</td>
<td>&lt;0.01</td>
<td>0.07</td>
</tr>
</tbody>
</table>

\(^1\) Control (CON) = rotationally stocked only. Distillers (DIST) = rotationally stocked supplemented with distillers dried grains with solubles. Silage (SIL) = rotationally stocked with forage removed, stored, and fed back as silage.

\(^2\) Contrast across treatments within a group (SSS or FSS) for ADG for both years.

\(^3\) Steer BW when grazing started was 229 ± 11 kg.

\(^4\) Steer BW when grazing started was 248 ± 18 kg.

\(^5\) Contrast between group (SSS vs. FSS) within a treatment for ADG for both years.
In contrast, steer ADG in the DIST treatment was not different \( (P = 0.07) \) between the SSS and FSS. The discrepancy in steer ADG between SSS and FSS in the SIL and CON treatments was likely due to limited forage availability during the latter portion of the grazing period (Figure 2), especially in yr 2. The below average precipitation (Figure 5) influenced all treatments, but especially the SIL and CON because little to no feed from outside the system was brought in to supplement forage as was the case in the DIST treatment.

For the SIL treatment specifically, the limited forage regrowth resulted in the steers consuming silage almost exclusively at times instead of a pasture and silage combination. The mean IVTD and CP content of round-bale silage when fed to the steers was 740 and 115 g·kg\(^{-1}\) on a DM basis, respectively. Round-bale silage can have less nutritive value than the original forage, especially true protein content. The destructive nature of the fermentation process converts much of the true protein of the fresh forage (some of which may be rumen undegradable protein) to rumen degradable protein (McDonald, 1981; Titgemeyer and Löest, 2001). In addition, the silage was fed during periods of low energy value in the pasture. Titgemeyer and Löest (2001) found that the energy value of silage is less than the original forage, which may explain a portion of the less-than-anticipated ADG. However, because many of the products of fermentation are of equal or greater energy value than the original substrate, only DM is lost during the fermentation process and not GE value (McDonald, 1981). In addition, available forage of pastures in the SIL treatment was less than 2,000 kg·ha\(^{-1}\) during the last 4 wk of yr 2 (data not shown), which likely reduced forage intake (Minson, 1990).

Average daily gains of steers over the entire season were 0.76 (SEM = 0.03), 0.67 (SEM = 0.04), and 0.46 (SEM = 0.04) kg·d\(^{-1}\) for DIST, SIL, and CON, respectively. Steer ADG in the DIST and SIL treatments were not different \( (P = 0.09) \), and both were greater than the CON \( (P = 0.01) \). The difference between DIST and CON steer ADG was similar to the difference of DDGS supplemented and unsupplemented heifers of Morris et al. (2005). The greater nutritive value of available forage in the SIL treatment would encourage greater rates of intake by the steers compared with the CON and, thus, partially explain the greater ADG of the steers in the SIL treatment compared with steers in the CON treatment (Collins and Fritz, 2003; Mertens, 2007).

Steer ADG in the DIST treatment was less than anticipated. Several factors might account for this difference including the inability to accurately estimate steer selectively of high-quality plants (Kunkle et al., 2000). In addition, maintenance requirement for the steers was calculated for confined cattle. This requirement does not account for additional energy expended for grazing (Caton and Dhuyvetter, 1997). Grazing animals may expend 1.08 to 1.30 times more energy than confined cattle through forage intake and walking (Di Marco
and Aello, 2001). Also, the NDF intake was estimated to be 12.5 g·kg⁻¹ of BW·d⁻¹, which may not truly reflect the actual intake of the animal (Mertens, 1994; Ketelaars and Tolkamp, 1996). In addition, Loy et al. (2008) reported that feeding alternate day resulted in 10% less ADG than when supplemented daily. However, they did not feed on weekends, so the calves were not truly supplemented on alternate day as the steers in this study. Incidentally, Aiken et al. (2005) did not see a difference in ADG of calves grazing bermudagrass supplemented with ground corn every day compared with every other day.

Grazing patterns were more uniform in the SIL treatment compared with DIST and CON treatments. This was the result of removing excess forage as silage before the forage matured and produced stems the steers were reluctant to graze. Although the initial stocking rates were not different across all 3 treatments, steers in the SIL treatment essentially had a larger area to graze because refused forage was kept to a minimum. However, although effective grazing area was reduced in the DIST as a result of grazing behavior, total grazing days was extended by the importation of DDGS into the system.

In conclusion, results from this study indicate that consistent daily BW gains of stocker steers can be attained by adjusting the amount of DDGS supplement based on forage nutritive value. Feeding the minimal amount of DDGS to steers based on pasture characteristics for an attempted 0.9 kg·d⁻¹ ADG resulted in equivalent total BW gains compared with a system in which labor and equipment inputs were much greater (SIL). If a stocker operator does not have resources or ability to mow and store forage as silage, adjusting the amount of DDGS fed to steers is a viable option.

**LITERATURE CITED**


