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Case Study: Supplementation of cow-calf pairs grazing smooth bromegrass pastures with ethanol by-products and low-quality forages

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ABSTRACT

Multiparous, lactating, crossbred (Simmental × Angus) beef cows with spring-born calves at side (n = 16 per year; 4 per pasture) were used each of 3 yr to evaluate supplementing modified distillers grains plus solubles mixed with low-quality forage on cow and calf performance while grazing. Cow-calf pairs were assigned randomly to treatment with 2 replications (pasture) per year for 3 yr. Treatments were (1) recommended stocking rate of 9.46 animal-unit month/ha with no supplementation (CON) or (2) double the recommended stocking rate (18.9 animal-unit month/ha) and supplemented with a 30:70 modified distillers grains plus solubles:cornstalks (DM) mixture (SUPP). To replace 50% of grazed forage DMI, SUPP pairs were fed an average of 1.13% of BW (DM) over the grazing season. Pairs grazed adjacent smooth bromegrass pastures for 130 d during the summer. Gain was not different ($P = 0.19$) between SUPP and CON cows (0.28 vs. 0.19 kg/d, respectively). Ending cow BW was not affected ($P = 0.46$) by treatment. Similarly, calf gain was not affected ($P = 0.31$) by supplementation. In studies where confined cow-calf pairs were fed average-quality (IVDMD = 52.9%) forage, DMI was 2.58% of pair BW. Based on these data, CON and SUPP pairs consumed 18.6 and 19.1 kg of DM, respectively, of total feed per pair daily. The SUPP pairs consumed 7.1 kg of DM/pair daily of the supplement, replacing approximately 35% of grazed forage intake. These data suggest mixtures of ethanol co-products and low-quality forages can be supplemented to replace grazed forage intake of cattle, allowing for increased stocking rate without affecting animal performance.

Key words: cow-calf pairs, distillers grains, forage replacement, supplementation

INTRODUCTION

Across the Midwest, pasture for beef production systems has become scarce and high priced as grain crop production has expanded (Wright and Wimberly, 2013). Concurrently, crop residues (Ward, 1978; Watson et al., 2015) and corn co-products from ethanol production (Klopfenstein et al., 2008) represent feed resources for beef production that are becoming more abundant, and opportunities to expand their use remain. Investigating alternative management strategies to increase pasture stocking rate and maintain beef production on finite resources is warranted. A practical approach to increase stocking rate may be to replace a portion of the grazed forage by supplementing low-quality crop residues mixed with co-products. Theoretically, replacing approximately 50% of the grazed forage with supplemental feed would support a 2-fold increase in stocking rate. Therefore, the objectives of this multiyear experiment were to evaluate the effects of supplementing modified distillers grains plus solubles (**MDGS**) mixed with low-quality crop residues to cow-calf pairs grazing smooth bromegrass pastures on (1) cow and calf performance and (2) production economics.

MATERIALS AND METHODS

All procedures and facilities described in the following experiment were approved by the University of Nebraska–Lincoln Institutional Animal Care and Use Committee. Multiparous (8.9 ± 4 yr of age), nonpregnant, crossbred (Simmental × Angus), lactating beef cows with spring-born calves at side were used in a 3-yr experiment conducted on smooth bromegrass (*Bromus inermis*) pastures at the University of Nebraska–Lincoln Agricultural Research and Development Center located near Mead, Nebraska (41°13′N, 96°29′W; elevation 369 m). In a completely randomized design, cow-calf pairs (n = 16 per year; 4 per pasture) were stratified by total pair BW and assigned randomly within strata to 1 of 2 treatments with 2 replications (pasture) per treatment each year. Across all 3 yr there were a total of 48 cow-calf pairs grazing 12 pasture replicates; data were collected on 16 pairs grazing 4 pastures each year. Treatments consisted of pastures stocked

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at (1) the recommended stocking rate of 9.46 animal-unit month (**AUM**)/ha without supplementation (**CON**) or (2) double the recommended stocking rate (18.9 AUM/ha) with supplementation (**SUPP**). Pastures were 2.8 and 1.4 ha, respectively. Pastures were fertilized with 90 kg of N/ha in the spring before the onset of the experiment. Pairs were stocked continuously on smooth bromegrass pastures from early May until mid September annually (130 d).

Cattle Management

Each year before the beginning of the experiment, cows were located at the University of Nebraska–Lincoln Dalbey-Halleck Research Unit near Virginia in southeast Nebraska. Cows were maintained on dormant smooth bromegrass pastures and received ad libitum access to alfalfa (*Medicago sativa*) and smooth bromegrass hay during calving. Mean calving dates were March 13, March 25, and March 25 for calves born in 2011, 2012, and 2013, respectively. Cows were vaccinated approximately 1 mo before calving against bovine rotavirus, bovine coronavirus, *Escherichia coli*, and *Clostridium perfringens* type C (Scour Bos 9; Elanco Animal Health, Greenfield, IN). Within 24 h of parturition, calving date, calf birth weight, and sex were recorded, and male progeny were band castrated. Approximately 3 wk before initiation of the experiment, all calves were vaccinated against *Clostridium chauvoei*, *Clostridium septicum*, *Clostridium novyi*, *Clostridium sordellii*, *C. perfringens* types C and D (Ultrabac 7; Zoetis Inc., New York, NY), and cows and calves were transported from the Dalbey-Halleck Research Unit to Agricultural Research and Development Center (approximately 121 km). Cows were marketed upon completion of the experiment each year. Thus, different cows were used for treatments each year.

The supplement fed in all years was a 30:70 ratio (DM basis) of MDGS and ground cornstalks designed to replace approximately 50% of the estimated grazed forage DMI, allowing for the 2-fold increase in stocking rate by the SUPP pairs. Ground cornstalks were chosen as a supplement ingredient to provide rumen fill, and MDGS was added at a minimal level necessary to encourage consumption of the low-quality forage. Based on data with confined cow-calf pairs fed average-quality forage (IVDMD = 53%; Meyer et al., 2012), predicted total forage DMI was calculated as 2.58% of average pair BW throughout the grazing period. Therefore, total estimated DMI was calculated retrospectively based on average pair BW for each treatment. It was anticipated grazed forage intake would be greatest early in the grazing season and decline with seasonal advancement. As a result, pairs were supplemented at 0.6% of BW (DM) at experiment initiation with increasing levels throughout the season on a weekly basis to account for (1) declining grazed forage quality and quantity and (2) increasing consumption by the calf. To encourage pairs to begin consuming the supplement, a 50:50 ratio of MDGS to cornstalks (DM) was initially fed, with cornstalks increasing and MDGS decreasing by 2 percentage unit increments daily until the 30:70 ratio was obtained (10 d). Before the beginning of the experiment, large-round cornstalk bales were ground (Mighty Giant; Jones Manufacturing Co., Beemer, NE) to pass through a 2.54-cm screen. Ground cornstalks and MDGS were stored separately in a partially enclosed commodity bay with concrete flooring before feeding. The supplement was mixed fresh daily using a truck-mounted feed mixer (Roto-Mix, Dodge City, KS), and water was added to reduce the DM content to 30% to enhance palatability and prevent sorting.

Supplemented pairs were group fed once daily in metal feed bunks with at least 0.9 m of linear bunk space per pair. Bunks were evaluated, and feed refusals (if present) were removed and sampled daily. Refusals were sampled for DM determination using a 60°C forced-air oven for 48 h, and supplement intake was subsequently calculated on a DM basis for each pasture.

Two-day consecutive cow and calf BW measurements (Stock et al., 1983) were recorded before and upon completion of the experiment to determine cow BW change and calf gain throughout the grazing period. Before collecting BW, pairs grazed a common pasture for a minimum of 5 d to minimize variation in gastrointestinal-tract fill. On weigh days, cattle were pulled from pasture at 0630 h, weighed, and returned to the pasture.

Pasture Performance

Although the primary objective of this experiment was cow and calf performance, a secondary objective was to observe effects of the SUPP treatment on pastures. Three pastures adjacent to pastures used in this experiment were used to estimate forage production. These pastures were grazed by yearling steers stocked at 9.9 AUM/ha without supplementation (Watson et al., 2012). The adjacent pastures were seeded at the same time (1990) and with the same brome variety (Lincoln) as the pastures used in the current experiment. All pastures were fertilized annually in the spring with 90 kg of N/ha. Eight exclosures (1 m^2) were located randomly in each pasture after N fertilization but before initiation of grazing. All standing vegetation was clipped at ground level within a 300-cm^2 quadrat placed in each exclosure. Clipping was done in late June and early October to account for total season forage production.

Pastures used in the current experiment had the same treatments applied by dry cows (Doerr et al., 2012) and yearling steers the 2 previous years. Therefore, these pastures had the same treatments applied for 5 yr (2009 to 2013). Forage production was measured in one replication of the pastures in 2014 using exclosures (clipping all vegetation within a 300-cm^2 quadrat) to determine carryover effects of the 5 yr of treatments (9 exclosures in the control pasture and 4 in the SUPP pasture). Forage production data were used to calculate harvest efficiency for treatments. Harvest efficiency (%) was calculated as (cow and calf intake/forage yield) × 100 (Smart et al., 2010).

Data Analysis

Data were analyzed using PROC MIXED of SAS (SAS Institute Inc., Cary, NC) as a completely randomized design with pasture serving as the experimental unit (4 pastures per year). Data are reported as pooled across all 3 yr. All analyses included the fixed effect of supplementation treatment, and year was considered a random effect. Because the proportion of steer and heifer calves was not equal between treatments, calf sex was initially included as a covariate in the model statement but was ultimately removed because it was not significant for all variables tested ($P > 0.10$). Significance was declared at $P \leq 0.05$, and tendencies are discussed at $P \leq 0.10$.

Economic Analysis

To evaluate the economics of supplementing to increase stocking rate, a partial budget analysis was conducted. For the analysis, pasture rental fees, feed prices, and other production costs were entered into a partial-budget Microsoft Excel (Microsoft, Redmond, WA) spreadsheet (Tigner, 2015). The analysis was completed to model a 200-pair cow-calf enterprise located in eastern Nebraska with the primary assumption that pasture for summer grazing was available for one half (100 pairs) of the cowherd. With limited resources, grazing additional rented pasture sufficient for the remaining 100 pairs or double stocking and providing supplement during the summer grazing season were options considered. For the budget analysis, it was assumed that there would be no decrease or increase in net income between management options because performance and herd inventory would remain unchanged. Therefore, economic differences between management systems would be due to changes in production costs.

Monthly grazing rental fees for eastern Nebraska were valued at $64.55/pair ($2.15/d; Jansen and Wilson, 2015). Freight expense for shipping cattle to and from pastures was calculated at $2.48/km ($4.00/loaded mile) assuming 3 semitruck loads for 100 pairs. It was assumed that pasture for 100 pairs could be rented 16.1 km (10 miles) away. Feed costs were compiled using data from weekly published feed price reports (USDA-AMS, 2015). Calculated cost for grinding baled cornstalk residue was $12.00/907 kg. Feed needs included a 5% shrink for MDGS and 10% for cornstalks. Yardage expense associated with checking and maintaining fence and caring for cattle was charged at $0.10/pair daily for CON cattle on pasture and $0.20/pair daily for SUPP cattle on pasture to account for increased equipment costs of mixing and delivering the feed. However, equipment necessary for feeding was considered already owned by the enterprise. It was assumed that supplement would be fed in a bunk. Allowing for 0.9 m of linear bunk space for each cow-calf pair requires 50 bunks that are 3.6 m in length. Therefore, bunk costs were included with a total one-time cost of $20,000 (50 bunks at $400/bunk) but were prorated across their assumed lifetime of 10 yr. Additional costs associated with breeding and salt–mineral supplementation were not different between management systems and, thus, were not included in the analysis.

RESULTS AND DISCUSSION

Cattle performance and supplement intake data are presented in Table 1. By design, cow age and initial BW were not different between treatments ($P \geq 0.69$). Both ending cow BW and gain were similar for SUPP and CON cows ($P \geq 0.19$). Calf age at the onset of the experiment, initial BW, and ADG were not different ($P \geq 0.18$) between SUPP and CON pairs. There was a 15-kg increase in ending BW for SUPP calves compared with CON that was not significant ($P = 0.08$); much of this difference was due to differences in initial BW. Although no attempt was made to measure the amount of supplement consumed by the calves, calves were observed at the bunk with their dams and appeared to be eating supplement daily. With no significant differences in cow or calf performance between treatments, the SUPP treatment appears to be a viable option when land resources are limited.

The results observed in the current experiment generally concur with that reported by other investigators. Cows double stocked and supplemented with a 30:70 ratio (DM) of wet distillers grains plus solubles (**WDGS**) and wheat straw tended to have greater ADG compared with those grazing at a recommended stocking rate in similar work on upland native Sandhills range (Nuttelman et al., 2010). Interestingly, calf performance was not affected by supplementation. In a different experiment by the same authors, both cow and calf ADG were improved by feeding a 45:55 ratio of WDGS and grass hay to double stocked pairs. The researchers attributed the improvement in calf ADG to increased milk production by the dam due to intake of a high quality feed, direct consumption of the supplement by the calves, or a combination of both factors (Nuttelman et al., 2010). Also in agreement, nonpregnant, nonlactating cows grazing smooth bromegrass had numerically greater ADG when double stocked and supplemented with a 35:65 blend of Golden Synergy (40% wet corn gluten feed and 60% MDGS; Archer Daniels Midland Company, Columbus, NE) and wheat straw (Doerr et al., 2012). Likewise, ADG of yearling steers grazing upland native Sandhills range at twice the recommended stocking rate was improved by supplementing a mixture of 60% forage (wheat straw or grass hay) and 40% WDGS (DM basis; Villasanti et al., 2011). The supplementation rate in the current experiment was designed to replace grazed forage intake rather than improve performance. The small numerical increase in performance by SUPP pairs is logical, given the supplement would contain more energy than the grass it replaced. Data from Watson et al. (2012) indicated IVDMD of smooth bromegrass diet samples decreased

Table 1. Performance of cow-calf pairs grazing smooth bromegrass pastures by treatment

	Treatment[1]			
Item	CON	SUPP	SEM	*P*-value
Pastures, n	6	6		
Cow				
Age, yr	8.6	9.0	0.7	0.69
Initial BW, kg	563	560	11	0.73
Ending BW, kg	588	597	19	0.46
ADG, kg	0.19	0.28	0.06	0.19
Calf				
Age, d	47	50	3.3	0.48
Initial BW, kg	80	88	5	0.18
Ending BW, kg	213	228	19	0.08
ADG, kg	1.03	1.08	0.08	0.31
Grazed forage intake,[2] kg of DM/pair	18.6	12.0		
Supplement intake, kg of DM/pair	—	7.1		
Total DMI, kg/pair	18.6	19.1		

[1]CON = pairs grazed at recommended stocking rate [9.46 animal-unit month (AUM)/ha] without supplementation; SUPP = pairs grazed at double the recommended stocking rate (18.9 AUM/ha) and received 50% of estimated daily intake of 30:70 distillers grains:cornstalks mixture, DM basis.

[2]Calculated values based on BW and DMI data collected by Meyer et al. (2012).

from almost 69% in May to 51% in September, averaging approximately 59%. This is slightly lower than the 63% TDN content of the supplement in the current experiment.

In addition to greater TDN content, the supplement had greater RUP content compared with the grass it replaced. Buckner et al. (2013) reported that brome diet samples contained only 0.92% digestible RUP as a percentage of DM. The supplement contained approximately 5.8% digestible RUP. Therefore, the supplemented pairs consumed about 3 times more RUP than the control cattle, 522 g/d compared with 171 g/d, respectively. The metabolizable protein needs of the lactating cow and the young growing calf are high, and the RUP from the supplement helps to meet these requirements.

Across all 3 yr, average total pair BW was 722 and 737 kg for CON and SUPP pairs, respectively. Based on these BW and data from Meyer et al. (2012), total estimated DMI was calculated to be 18.6 and 19.1 kg/pair daily for CON and SUPP, respectively. For SUPP pairs, supplement intake averaged 7.1 kg of DM/d throughout the season. By difference, grazed forage intake was calculated as 12.0 kg/d. This suggests the supplement reduced grazed forage intake by 35%, and 0.93 kg of grazed forage was replaced by every 1 kg of supplement fed. It was assumed that stocking rate changes between the SUPP and CON treatments did not affect intake, although this was not directly measured. Similar research conducted in the Sandhills (Nuttelman et al., 2010) with cow-calf pairs demonstrated grazed forage replacement values of approximately 40 to 50% when a 30:70 ratio (DM basis) of WDGS and wheat straw was fed. Daily forage disappearance per cow-calf pair was not influenced by supplementation of a 45:55 ratio of WDGS and grass hay in other work by Nuttelman et al. (2010). Doerr et al. (2012) noted that a blend of 35% by-product and 65% wheat straw (DM) decreased smooth brome intake by 48%. Range forage intake of double stocked yearling steers was reduced 44 to 54% by feeding a low-quality forage and WDGS (Villasanti et al., 2011). However, supplement characteristics appear to be important in determining substitution effects on forage intake. Grazed forage intake was not reduced when yearling steers were supplemented only dried distillers grains plus solubles in studies by Gustad et al. (2008) and Stalker et al. (2012). Although previous work (MacDonald et al., 2007; Griffin et al., 2012) has suggested a substitution effect on forage intake when distillers grains are fed in forage-based diets, reductions in forage intake have not been great enough to allow for a 2-fold increase in stocking rate (Stalker et al., 2012). This indicates using fibrous low-quality forages in the supplement is essential to reducing voluntary grazed forage DMI and achieving significant forage replacement rates. This concurs with the well-established concept that intake of forage-fed cattle is regulated by rumen fill and digesta passage (NASEM, 2016).

Forage Production

Table 2 reports rainfall and forage production in pastures adjacent to the pastures used in the current experiment. Production in 2012 was lower than 2011 and 2013 because of limited rainfall. Based on the estimated forage intakes, harvest efficiency in the control pastures ranged from 28.7 to 49.2% across years. Calculated harvest efficiency was numerically greater in the SUPP pastures, ranging from 36.2 to 64.3%. Visual observation suggested that the pairs used the SUPP pastures to a greater degree early in the grazing season and depended more on the supplemental feed later in the season. This greater utilization early in the season maintained the brome in a more vegetative state throughout the grazing season. Because the grazing pattern was different and harvest efficiency was greater with the SUPP treatment, subsequent forage production was of interest.

Forage production was measured the year following this experiment to determine the effects of 5 yr of the CON and SUPP treatments being applied to these pastures. Forage production measured on July 10, 2014, was 9,312 kg/ha for the CON pasture and 10,558 kg/ha for the SUPP pasture. We conclude that the grazing pattern and higher harvest efficiency in the SUPP treatment actually had a positive effect on the pastures. A partial explanation for increased forage production in the SUPP pastures might be added N from the supplement. The supplemented feed contained 2% N and supplied 18.5 kg of N/pair during the grazing season. At 19% protein in the gain (NASEM, 2016), the calves removed about 4.3 kg of N and the cows would have removed about 0.10 kg of N/yr. Assuming one half the gain came from the supplemental feed, then about 2.2 kg of N was removed by a pair. The net excretion would be 16.3 kg of N/pair or 23 kg of N/ha. This may explain the greater forage production in 2014 because of carryover of N deposited by the pairs during the previous 3 yr. It also suggests that forage production in the SUPP treatment pastures during this experiment may have been greater than that in the control pastures.

Table 2. Precipitation and forage production by year

Item	2011	2012	2013
Rainfall,[1] cm	66.2	41.6	55.4
Forage yield,[2] kg of DM/ha	11,785	6,250	11,535
Harvest efficiency (CON),[3] %	33.0	49.2	28.7
Harvest efficiency (SUPP),[4] %	42.0	64.3	36.2

[1]October through August.

[2]Estimated from measurements taken on adjacent pastures.

[3]Harvest efficiency (%) = (Intake/Forage yield) × 100 (Smart et al., 2010). Harvest efficiency by pairs on the control treatment (CON), stocked at 9.46 animal-unit month (AUM)/ha.

[4]Harvest efficiency by pairs on the supplement treatment (SUPP), stocked at 18.9 AUM/ha.

Economic Analysis

Based on current production costs and analysis assumptions, double stocking available acres and providing supplement, as opposed to leasing additional grazing land, resulted in a gain of $4,720.00 (Table 3) or a $23.60 increase per cow-calf pair. This is primarily due to the relationship between pasture rental fees and feed prices. At a pasture rental fee of $64.55/mo, the daily cost per cow-calf pair is $2.15. At feed prices ($/907 kg of DM, including grinding and shrink) of $116.00 and $89.00 for MDGS and cornstalks, respectively, the cost of the daily supplement per pair equals $0.76. Thus, daily feed costs were $2.15/pair for CON and $1.84/pair for SUPP with double stocking ($0.76 for supplement + $1.08 for grass).

Using the partial budget to evaluate all changes in costs, pasture rental fees would have to decrease 14.5% ($55.20/mo for a cow-calf pair) for the treatments to have equal profit. Conversely, if both MDGS and cornstalk prices increased 23%, the treatments would have equal profit. This would be a cost of $106.00/907 kg of DM (including grinding and 10% shrink) for cornstalks and $142.00/907 kg of DM (including 5% shrink) for MDGS.

Double stocking was feasible in this experiment, likely due to both increased forage production in SUPP pastures from increased N deposition and forage intake replacement with the supplement. At the assumed price levels and production costs, double stocking and supplementing was more profitable.

IMPLICATIONS

Supplementing cow-calf pairs grazing smooth bromegrass pastures with a mixture of ethanol co-products and corn residue reduced estimated grazed forage intake without affecting animal performance. This may be a feasible management practice to increase stocking rate when pasture for grazing is limited. This technique is likely more applicable in higher-rainfall areas that support the growth of productive cool-season grass species such as smooth bromegrass than on rangelands in more subhumid to semiarid climates, because there are fewer potential risks of overgrazing. Likewise, in such areas ethanol co-products and crop residues are more abundant, and increased competition between uses of land (cropping or pasture grazing) may exist. The price relationship between pasture and feed supplement ingredients dictates the economics of supplementation to increase stocking rate.

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Table 3. Partial budget analysis of renting pasture for cow-calf pairs or supplementing to replace forage intake[1]

Increased costs, $	Amount
CON	
Pasture rental for 100 pairs	32,250
150 d at $2.15/d[2]	
Cattle and fence care, $0.10/pair daily (150 d and 200 pairs)	3,000
Cattle freight to rented pasture, $2.48/loaded km at 16.1 km, 3 loads, 2 ways	240
Total costs	35,490
SUPP	
Distillers grains ($116.00/907 kg)[3]	8,158
Cornstalks ($89.00/907 kg)[4]	14,612
Cattle and fence care	3,000
Feed delivery, $0.20/pair daily (150 d and 200 pairs)	3,000
50 bunks, $400.00/bunk, 10-yr lifetime	2,000
Total costs	30,770
Change in net income	4,720

[1]Partial budget evaluated changes in costs due to replacing approximately 50% of the grazed forage with a 30:70 ratio of distillers grains and ground cornstalks supplement. Costs were modeled for a 200 cow-calf pair enterprise in eastern Nebraska with sufficient summer grazing for 100 pairs at recommended stocking rates. Remaining forage needs were met with rented pasture hectares (CON) or double-stocking available hectares and supplementing (SUPP).

[2]Pasture rental was charged at $64.55/mo for each pair (Jansen and Wilson, 2015).

[3]Distillers grains were priced at $110.00/907 kg of DM plus a 5% shrink.

[4]Cornstalks were priced at $68.00/907 kg of DM plus $12.00/907 kg for grinding and 10% shrink.

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