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Using corn stover and dried distillers grains with solubles to conserve stockpiled forages and improve reproductive performance and progeny growth in fall-calving beef cows[1]

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ABSTRACT

Angus-cross, fall-calving beef cows (n = 153) were used in this experiment. The objective was to determine whether incorporating a period of corn stover and dried distiller grains with solubles (DDGS) feeding into a preexisting nutritional program that included grazing stockpiled tall fescue affects reproductive performance and progeny growth. On Julian d 267 cows were stratified and allotted by BW, BCS, and calving date (if calved) to receive 1 of 2 isocaloric dietary treatments through timed AI (TAI; Julian d 336): stockpiled tall fescue (CON) or corn stover plus DDGS (DG; DDGS at 0.7% of BW/d). Following timed AI, CON cows were fed grass hay, and DG cows were placed on stockpiled tall fescue until grass was exhausted (Julian d 20) and then fed grass hay. Cow BW and BCS did not differ during the supplementation period. The proportion of cows cycling at breeding-season initiation tended (P = 0.06) to be greater in CON- (92.2%) than in DG-treated (80.6%) cows. Pregnancy rates from timed AI did not differ between the CON (42.4%) and DG (50.0%) treatment. However, breeding-season pregnancy rates were greater (P = 0.03) in the DG (89.6%) than CON (74.2%) treatment. Progeny from cows fed DG were heavier at 62 d of age and at weaning (P ≤ 0.03) when compared with CON progeny. In summary, including a dietary period of corn stover and DDGS to a traditional management practice of grazing stockpiled tall fescue and feeding hay resulted in greater breeding-season pregnancy rates and heavier progeny.

Key words: corn stover, dried distillers grains with solubles, fertility, progeny growth, stockpile fescue

INTRODUCTION

To remain profitable and thrive within the beef industry, producers must find ways to cut production costs without impairing productivity. Because feed, especially harvested forage, is the largest cost in cow-calf production systems, finding economical, alternative feed sources and feeding strategies may be the easiest way to maintain or increase profitability. A viable way to reduce feed costs, especially in fall-calving herds, is to stockpile forages. In addition, in the Corn Belt, where corn residue and corn by-products such as distillers grains with soluble (**DDGS**) are readily available, combining the use of stockpiled forages, corn residue, and corn coproducts may be a cost-effective management practice that allows

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for reduced use of harvested forages in fall-calving beef herds. Braungardt et al. (2010) reported that wintering diets containing corn stalks and DDGS for spring-calving cows were up to 33% less expensive than feeding ad libitum alfalfa-mix hay.

To date there is little, if any, research currently available regarding the effects of stockpiled forage versus corn residue with supplemented protein on reproductive efficiency in fall-calving beef cows. Research by Hitz and Russell (1998) noted that pregnant spring-calving cows grazing fall stockpiled tall fescue–alfalfa pasture gained more BW than cows grazing corn residue alone. Conversely, Larson et al. (2009) observed that pregnant spring-calving cows grazing fall corn residue had a greater prebreeding BW and BCS than cows grazing winter range. These conflicting data illustrate the need to define production schemes that optimize reproductive efficiency in fall-calving cows. Martin et al. (2007) and Harris et al. (2008) indicated that low-level supplementation of DDGS before breeding may enhance reproductive performance and increase pregnancy rates in spring-calving cows. Therefore, we hypothesized that a management system that combines the feeding of corn stover and DDGS before breeding with grazing of stockpiled tall fescue after breeding will improve reproductive efficiency in fall-calving cows and increase preweaning calf performance.

MATERIALS AND METHODS

Animals and Diets

All cows were handled in accordance with procedures approved by the Purdue Animal Care and Use Committee. Multiparous, Angus-Simmental cows (n = 153; BW = 540 ± 71 kg; BCS = 5.4 ± 0.5; age = 5.4 ± 2.1 yr) at the Southern Indiana Purdue Agricultural Center in Dubois, Indiana, were used in a randomized complete block design to assess if a nutritional program that incorporates corn stover and DDGS in combination with preexisting stockpile grazing in fall-calving cows can be used to reduce harvested forage needs without negatively affecting reproduction or preweaning progeny growth.

Before initiation of the experiment, all available stockpiles, composed primarily of endophyte-infected tall fescue, were divided into 2 equal parts, and each treatment was given 93 ha for grazing during their designated period. At Julian d 267, cows were blocked by age, and within age, cows were stratified by BCS, BW (which was adjusted for gravid uterine weight when applicable; Ferrell et al., 1976), and either calving date or projected calving date and allotted to 1 of 2 dietary management schemes. In addition, calf sire and calf sex (when applicable) were balanced between treatments. It should be noted that the calving season began on Julian d 243 and concluded on Julian d 302. At time of nutritional treatment initiation, 103 of 153 cows had calved [n = 50 in control (**CON**); n = 53 in DDGS]. Treatments (Table 1) were designed to deliver a similar amount of NE_g and to meet or exceed the protein, vitamin, and mineral requirements (NRC, 2000) of a lactating, fall-calving multiparous cow. Figure 1 illustrates the dietary management scheme timeline. Treatments included ad libitum grazing of stockpiled tall fescue (CON; n = 77) or ad libitum baled corn stover and DDGS supplemented to meet the energy requirements of a fall-calving cow in early lactation (**DG**; DDGS at 0.7% of BW/d; n = 76). Baled corn stover was used as a feed resource because grazing of corn residue was not feasible at the research location. Therefore, the DG treatment was only fed from the beginning of corn harvest (Julian d 267) until 6 d after timed AI (**TAI**; Julian d 342) to mimic a period of time in which producers may have access to corn residue for grazing. The day after TAI (Julian d 337), CON cows were moved to a dry lot and fed large round bales of tall fescue hay for the remainder of the winter because their allotted stockpiles were exhausted. Cows on the DG treatment were placed on their allotment of stockpiled tall fescue (Julian d 342) until stockpiles were exhausted (Julian d 20) and then placed in a drylot and fed grass hay identical to that of the CON treatment.

Diets were formulated to deliver a similar amount of NE_g between treatments and for cow BW to be similar from experiment initiation through TAI. Diets were formulated using individual ingredient chemical composition analysis obtained by wet chemistry methods (AOAC, 1990) before the start of the experiment (Sure-Tech Laboratories, Indianapolis, IN). For the CON treatment, ad libitum daily DMI from the stockpiled tall fescue pasture was estimated using the following formula (NRC, 2000) for lactating beef cows:

$$\text{DMI} = \{[\text{shrunk BW}^{0.75} \times (0.04997 \times \text{NE}_m{}^2 + 0.03840)/\text{NE}_m] \times (\text{TEMP1}) \times (\text{MUD1}) + (0.2 \times \text{Yn})\},$$

where adjustments for TEMP1 (temperature) and MUD1 (mud) were 1.00 and 1.00, respectively, and Yn was milk production in kilograms estimated at 10.9 kg/d.

Ad libitum daily DMI of corn stover was estimated using the same equation previously described. Once corn stover intake was estimated, DDGS supplementation rate was calculated so that the DG diet delivered a similar amount of NE_g per day as the CON treatment. Corn stover bales were presented for consumption in fence-line large bale feeders. The DG supplement, which consisted of DDGS and limestone to balance the Ca:P ratio was delivered in concrete fence-line bunks once daily at approximately 0900 h. It should be noted that because of bunk design and DDGS delivery, it was impossible to restrict access of DG progeny to DDGS. However, all DDGS were consumed within approximately 15 min of delivery and before cows exiting the bunk area. Therefore, calf access to DDGS was severely limited.

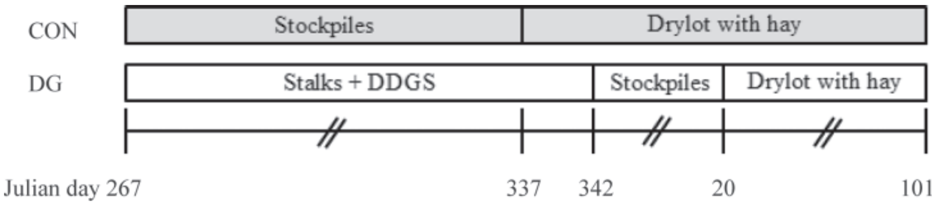

Figure 1. Dietary treatment scheme implemented in lactating, multiparous beef cows to determine the effect of management scheme on reproductive efficiency of the cow and preweaning growth of the progeny. Treatments included ad libitum access to stockpiled tall fescue pasture until stockpiles were exhausted, followed by ad libitum hay consumption in a drylot (CON), or ad libitum access to corn residue with supplemental dried distillers grains with solubles (DDGS), followed by ad libitum stockpile grazing until stockpiles were exhausted, at which point cows were given ad libitum access to hay in a drylot (DG). Cows were synchronized for ovulation and AI on a timed basis on Julian d 336. Steer progeny were weaned on Julian d 40, and heifer progeny were weaned on Julian d 101.

Initial BW and initial BCS (1 = emaciated, 9 = obese; Wagner et al., 1988) was taken the day before treatment initiation. Subsequent BW and BCS were assessed 28 and 56 d after dietary treatment initiation and at steer progeny weaning (146 ± 16 d in lactation), which occurred 63 d after treatments concluded. All BCS assessments were conducted by the same person throughout the experiment and recorded on the basis of a plus-minus system in addition to whole number scores (i.e., a BCS 5−, 5, and 5+ was equal to 4.67, 5, and 5.33). Eleven CON and 8 DG cows were removed from the data set because of various non-treatment-related issues including the failure to calve, calf mortality, and cow mortality.

Table 1. Dietary ingredients, nutrient composition, and estimated nutrient intake of diets fed to fall-calving beef cows from periparturition through timed AI[1,2,3]

Item	CON	DG
Ingredient, % of dietary DM		
Dried distillers grains with solubles	—	28.5
Corn stalks	—	70.3
Limestone	—	0.5
Stockpiled tall fescue	99.2	—
Mineral[4]	0.8	0.7
DMI, kg/d		
Dried distillers grains with solubles	—	3.47
Corn stover[5]	—	8.11
Limestone	—	0.07
Stockpiled tall fescue[5]	12.5	—
Mineral pack	0.11	0.09
Calculated nutrient content[5]		
CP, % of diet DM	16.9	12.9
NE_g, Mcal/kg of diet DM	0.66	0.72
Calculated nutrient intake		
CP, g/d	2,122	1,507
NE_g, Mcal/d	0.61	0.57

[1]Values expressed on a DM basis.

[2]Chemical composition of hay delivered to both treatments after stockpiles were consumed on DM basis: 88% DM, 0.63 NE_g, 15.1% CP, 0.51% Ca, 0.37% P, 62% NDF.

[3]Treatments: ad libitum access to stockpiled tall fescue pasture (CON), or ad libitum access to corn residue with supplemental dried distillers grains with solubles (DG).

[4]Mineral delivered for ad libitum consumption contained 22% salt, 2% Mg, 11% Ca, 4% P, 0.5% K, 1.0% S, 1,600 mg/kg Cu, 3,200 mg/kg Zn, 35 mg/kg Se, 65 mg/kg I, 15 mg/kg Co, 5,000 mg/kg Mn, 550,000 IU/kg vitamin A, and 550 IU/kg vitamin E.

[5]Predicted daily ad libitum DMI of corn stover and stockpiled tall fescue based on NE_m of corn stover and stockpiled tall fescue samples taken before initiation of the experiment.

Resumption of Cyclicity and Plasma Urea Nitrogen

Blood samples were collected 7 d before and on the day that ovulation synchronization was initiated to assess the proportion of cows that had resumed estrus-cycle activity. Blood samples were collected via coccygeal venipuncture in 6-mL tubes containing EDTA (BD Vacutainer; Becton Dickinson, Franklin Lakes, NJ) and immediately placed on ice. Samples were centrifuged at 1,750 × g for 25 min at 4°C; plasma was recovered, transferred to 5-mL polystyrene tubes, and frozen at −20°C until analysis for progesterone concentration. Progesterone concentration was determined using a commercially available RIA kit (Coat-A-Count, Siemens Medical Solutions Diagnostics, Los Angeles, CA). Across 2 assays, the average intraassay CV was 1.7% and the interassay CV for pooled plasma samples containing 0.19 and 6.35 ng/mL of progesterone were 2.7 and 5.0%, respectively. The average sensitivity across assays was 0.17 ng/mL (95% CI). For assessment of estrous cycling status, cows that had progesterone concentrations ≥1 ng/mL in at least 1 of the 2 blood samples were considered to have resumed cycles before ovulation synchronization.

Plasma samples obtained on the day that ovulation synchronization was initiated were also analyzed for circulating concentrations of plasma urea nitrogen (**PUN**; Gunn et al., 2009). Serum samples were analyzed for PUN concentrations using a commercial kit (Urea Nitrogen Procedure No. 0580, Stanbio Laboratory, Boerne, TX). Samples were read in 96-well polystyrene plates (Becton, Dickinson and Co.) on an Opsys MR microplate reader (Dynex Technologies Inc., Chantilly, VA) at 530 nm. Across 6 assays, the average intraassay CV was 3.4%, and the interassay CV for a pooled serum sample containing 4.31 mg/dL of urea nitrogen was 3.0%.

Ovulation Synchronization and Breeding

At 69 ± 16 d postpartum (Julian d 328), all cows were enrolled in the 5-d CO-Synch + CIDR protocol that consisted of insertion of an intravaginal progesterone insert containing 1.32 g of progesterone (CIDR, Pfizer Animal Health, New York, NY) concurrent with administration of 100 μg of GnRH (Cystorelin, Merial Animal Health, Duluth, GA) at protocol initiation. Five days later the CIDR was removed, and 2 separate but simultaneous 25-mg injections of $PGF_{2\alpha}$ (Lutalyse, Pfizer Animal Health) were administered. At CIDR removal, all cows received tail paint (Tell Tail; FIL, 132 Mount Maunganui, New Zealand). At TAI, tail paint scores (**TPS**) were assessed (1 = tail paint completely removed; 2 = tail paint partially removed, obvious signs of receiving some rubs from mountings; 3 = no signs of having received mounts, tail paint undisturbed) as an indicator of estrus expression before TAI. On Julian d 336, 72 h after CIDR removal, all cows were TAI concurrent with GnRH administration (Cystorelin; 100 μg). Cows were AI by a single technician, and bulls were evenly stratified across treatment. Ten days following TAI, mature bulls that passed breeding soundness exams were placed with cows for the reminder of the 64-d breeding season. Bulls were removed on Julian d 35.

Pregnancy diagnosis was performed 33 d after TAI using transrectal ultrasonography to determine TAI pregnancy rates. Final pregnancy diagnosis was conducted via transrectal ultrasound, or palpation, or both, 42 d after the conclusion of the breeding season to determine breeding-season pregnancy rates. Specifically, cows that were confirmed pregnant to TAI at the initial pregnancy diagnosis were reconfirmed pregnant to that date via rectal palpation by a board-certified theriogenologist veterinarian with 35 yr of experience. Any cow that was not reconfirmed pregnant to TAI, as well as all cows not diagnosed pregnant to TAI at initial pregnancy diagnosis, were subjected to ultrasound to diagnose incidence of pregnancy over the duration of the breeding season.

Preweaning Progeny Growth

Calf BW was measured at birth, 62 ± 16 d of age (Julian d 321), 146 ± 16 d of age (Julian d 40), and again at weaning. Within this experiment, calf BW obtained at 146 ± 16 d of age coincided with weaning of steer calves for use on a subsequent experiment. Heifer calves were not weaned until 208 ± 18 d of age (Julian d 101).

Statistical Analysis

Differences between treatments for categorical data were analyzed using the GLIMMIX procedure of SAS (SAS Institute Inc., Cary, NC). All other data were analyzed using the MIXED procedures of SAS. For dependent variables of interest in cows, the model included the fixed main effect of treatment, and animal served as the experimental unit. In the analysis of both TAI pregnancy and overall breeding-season pregnancy rates, days postpartum served as a covariate within the model because some cows had not calved before treatment initiation. For progeny performance variables including BW and ADG, the initial model included the fixed main effects of both maternal treatment and progeny sex, as well as the appropriate maternal treatment × progeny sex interaction. However, the treatment × progeny sex interaction was not significant ($P > 0.10$) in any of the models and was removed. Moreover, because some cows were placed on experiment before parturition, an ancillary analysis was conducted within that subpopulation to determine whether maternal diet during gestation affected progeny growth rates differently than those cows only supplemented during early lactation. In all analyses, animal served as the experimental unit. In addition, the CORR procedure of SAS was used to analyze relationships among response variables both across and within treatments. A P-value ≤0.05 was identified as significant, whereas a P-value >0.05 and ≤0.10 was identified as a tendency approaching significance.

RESULTS AND DISCUSSION

Cow BW and BCS

As per the experimental design, neither cow BW ($P = 0.80$) nor BCS ($P = 0.66$) differed at treatment initiation (Table 2). Moreover, cow BW did not differ at ovulation synchronization or at weaning of the steer progeny ($P \geq 0.23$). Similarly, BCS did not differ at ovulation synchronization ($P = 0.36$). However, CON cows had greater BCS than DG cows at the time of steer progeny weaning (4.87 vs. 4.52, respectively; $P < 0.001$).

Reproductive Efficiency

Results of reproductive parameters are reported in Table 3. The number of days postpartum at initiation of ovulation synchronization was not different between treatments ($P = 0.93$). However, the proportion of cows that were determined to be cyclic at ovulation synchronization tended to be greater ($P = 0.06$) in CON- than

Table 2. Effect of dietary management system from periparturition until weaning on performance of fall-calving, lactating beef cows[1]

Item	CON	DG	SEM[2]	*P*-value
BW, kg				
Initial[3]	539	542	8.3	0.80
Ovulation synronization[4]	592	606	8.5	0.23
Weaning[5]	567	558	8.4	0.43
BCS[6]				
Initial[3]	5.41	5.45	0.06	0.66
Ovulation synronization[4]	5.29	5.35	0.05	0.36
Weaning[5]	4.87	4.52	0.05	<0.001

[1]Treatments included ad libitum access to stockpiled tall fescue pasture until stockpiles were exhausted, followed by ad libitum hay consumption in a drylot (CON), or ad libitum access to corn residue with supplemental dried distillers grains with solubles, followed by ad libitum stockpile grazing until stockpiles were exhausted, at which point cows were given ad libitum access to hay in a drylot (DG).

[2]Greater SEM presented (n = 77 for CON; n = 76 for DG at treatment initiation).

[3]Initial weight (periparturition) adjusted for gravid uterine weight, if necessary (Ferrell et al., 1976).

[4]Measurement taken at initiation of ovulation synchronization (Julian d 328; d 56 of experiment).

[5]Measurement taken at steer calf weaning (Julian d 40; 146 ± 16 d in lactation), 63 d after dietary treatments ended.

[6]BCS on a scale of 1 to 9 (1 = emaciated, 9 = obese; Wagner et al., 1988).

DG-treated cows. Similarly, PUN at ovulation synchronization was greater ($P < 0.001$) in CON- than DG-treated cows. Although average TPS ($P = 0.11$) and the proportion of cows with a TPS of 1 ($P = 0.24$) at TAI did not differ because of treatment, the proportion of cows that had either a TPS of 1 or 2 at TAI tended to be greater ($P = 0.07$) in DG- than CON-treated cows. Although TAI pregnancy rates did not differ between treatments ($P = 0.35$), overall breeding-season pregnancy rates were greater ($P = 0.03$) in DG- than CON-treated cows. Correlation analyses revealed that cyclicity ($P = 0.006$; r = 0.24) and proportion of cows with a TPS of 1 or 2 ($P = 0.04$; r = 0.18) were positively related to proportion of cows that became pregnant to TAI. Of cows that did become pregnant during the breeding season, average day of the year in which cows calved in the subsequent calving season did not differ because of treatment ($P = 0.79$; data not shown). Moreover, the birth BW of calves born in the subsequent

Table 3. Effect of dietary management system from periparturition until weaning on reproductive performance of fall-calving, lactating beef cows[1]

Item	CON	DG	SEM[2]	*P*-value
Days postpartum at timed AI	68.8	69.1	2.0	0.93
Cycling at ovulation synchronization, %	92.2	80.6		0.06
Plasma urea nitrogen,[3] mg/dL	14.32	11.6	0.37	<0.001
Tail paint score at timed AI[4]	2.30	2.06	0.11	0.11
Proportion of TPS 1,[5] %	27.3	36.8		0.24
Proportion of TPS 1 or 2,[5] %	41.8	57.4		0.07
Pregnancy rates, % (n)				
Timed AI	42.4 (28/66)	50.0 (34/68)		0.35
Breeding season	74.2 (49/66)	89.6 (61/68)		0.03

[1]Treatments included ad libitum access to stockpiled tall fescue pasture until stockpiles were exhausted, followed by ad libitum hay consumption in a drylot (CON), or ad libitum access to corn residue with supplemental dried distillers grains with solubles, followed by ad libitum stockpile grazing until stockpiles were exhausted, at which point cows were given ad libitum access to hay in a drylot (DG).

[2]Greater SEM presented (n = 66 for CON; n = 68 for DG for reproductive parameters).

[3]Plasma urea nitrogen concentrations determined in blood samples collected concurrent with CIDR insertion at the start of ovulation synchronization.

[4]Cows ovulation synchronized using 5-d CO-Synch + CIDR protocol.

[5]Tail paint scores (TPS) were recorded on cows at timed AI, 72 h post-$PGF_{2\alpha}$. 1 = no tail paint remaining; 2 = some tail paint remaining; 3 = tail paint undisturbed.

calving season to the experiment did not differ as a result of treatment ($P = 0.58$; data not shown).

Preweaning Progeny Growth

Results of preweaning progeny growth analysis are outlined in Table 4. As previously stated, because some cows were placed on the experiment before parturition, an ancillary analysis was conducted within that subpopulation to determine whether maternal diet during gestation affected progeny growth rates differently than those cows only supplemented during early lactation. No interaction was noted between incidence of calving before treatment initiation and treatment for any of the preweaning progeny growth parameters tested. Therefore preweaning progeny data were pooled within treatment. The proportion of bull calves born to cows on experiment did not differ between treatments ($P = 0.69$). Birth BW was greater in bull calves than heifer calves ($P = 0.04$; data not shown) and tended to be greater in calves born to DG-treated cows than calves born to CON-treated cows ($P = 0.08$). Nonetheless, preweaning ADG was greater ($P = 0.03$) in progeny of DG-treated cows than progeny of CON-treated cows. Moreover, calf BW was greater at Julian d 321 (64 ± 16 d of age; $P < 0.001$) and at weaning ($P = 0.03$) for progeny of DG-treated cows when compared with progeny of CON-treated cows.

Original Objectives

The primary objective of this experiment was to determine whether a nutritional management system that includes corn stover and supplemental DDGS could be incorporated into a traditional stockpiled tall fescue grazing system without negatively affecting cow reproductive efficiency or preweaning progeny growth compared with cows only grazing stockpiled forages. Specifically, cow cyclicity, TAI, and overall breeding season pregnancy rates, as well as progeny growth parameters, were studied. We hypothesized that a diet of corn stover and DDGS before TAI would not impair reproductive efficiency or preweaning progeny performance. Similar TAI pregnancy rates between treatments, as well as greater breeding-season pregnancy rates and increased progeny growth before weaning in corn stover and DDGS supplemented cows, support this hypothesis. Based on this nutritional management model, use of corn stover and supplemental DDGS before TAI in fall-calving cows resulted in 43 fewer days on hay. Although it is not clear why the DG treatment consumed all available stockpiled forage after only 43 d compared with 70 d that the CON treatment grazed stockpiles, it is likely because of the increased forage intake associated with older calves at the time of grazing as well as lack of regrowth coupled with trampling of forage leading to reduced forage availability. Although we were limited in this experiment to feeding harvested corn stover, if corn stover were grazed for the 75-d period in which stover was fed in this experiment, it seems reasonable that the DG treatment has the potential to extend the stockpiled grazing season and reduce the need for harvested hay.

Cow BW and BCS

Because metabolic energy status can dramatically alter reproductive function, initial prebreeding diets were formulated to both provide similar daily NE_g and maintain similar BW between treatments throughout the supplemental DDGS. Cow BW similarities were maintained between treatments not only through the DG supplementation period but also through weaning of steer calves, which occurred 63 d after termination of DDGS supplementation. Similarly, BCS did not differ between treatments at TAI; however, CON cows had a greater BCS at steer calf weaning than DG cows. The reason for differences in BCS in lieu of similar BW at weaning is not easily explained. However, this is similar to another experiment from our laboratory (Gunn, 2013) in which we observed suppressed BCS of DDGS-fed, first-parity, lactating heifers when compared with contemporaries of a similar BW maintained on a corn silage–based diet. This difference could be explained by potential protec-

Table 4. Effect of dietary management system from periparturition until weaning on progeny performance of fall-calving, lactating beef cows[1,2]

Item	CON	DG	SEM[3]	*P*-value
Sex of calves, % bulls	49.4	52.6		0.69
Calf BW, kg				
Birth	30.8	32.3	0.61	0.08
62 ± 16 d of age[4]	78.3	92.0	2.33	<0.001
146 ± 16 d of age[5]	138.1	143.6	3.1	0.21
Weaning[5,6]	167.9	179.7	3.8	0.03
Preweaning ADG, kg	0.771	0.827	0.018	0.03

[1]Sex of calf used as a covariate in calf performance data.

[2]Treatments included ad libitum access to stockpiled tall fescue pasture until stockpiles were exhausted, followed by ad libitum hay consumption in a drylot (CON); or ad libitum access to corn residue with supplemental dried distillers grains with solubles, followed by ad libitum stockpile grazing until stockpiles were exhausted, at which point cows were given ad libitum access to hay in a drylot (DG).

[3]Greater SEM presented (n = 66 for CON; n = 68 for DG).

[4]Conclusion of dietary treatments.

[5]Bull calves were weaned at 144 ± 16 d of age.

[6]Heifer calves were weaned at 208 ± 18 d of age.

tion of unsaturated fatty acids from ruminal biohydrogenation in DDGS-based diets (Vander Pol et al., 2009), which results in a more unsaturated fatty acid profile absorbed by the cow, causing a potential shift in body fat deposition away from subcutaneous to visceral fat. Even if such speculation is correct, it is unclear why a difference in BCS was not manifested in earlier assessments. Nonetheless, as treatment BW remained similar in lieu of BCS differences after supplement termination, GE status was assumed to be similar between treatments throughout the experiment and eliminated as a confounding factor in reproductive parameters.

It should be reiterated that baled corn stover was used in this experiment because grazing of corn residue was not feasible at the research location. Therefore, the DG treatment was only fed from the beginning of corn harvest (Julian d 267) until 6 d after TAI (Julian d 342) to mimic a period of time (75 d) in which producers may have access to corn residue for grazing. However, as with any grazing system, stocking rates and weathering of forage should be considered when grazing corn residue. Russell et al. (1993) reported that mid-gestation, spring-calving cows grazing corn residue for a 56-d period are more likely to gain BW when given an allowance of at least 1.64 ha of cropland. Therefore, to extrapolate to the current data, a stocking rate of 1 cow/2.2 ha of cropland is needed for a 72-d grazing period. However, as DG-treated cows in this experiment were given supplemental DDGS, BW would likely be maintained or gained on fewer hectares. Nonetheless, use of corn-residue, particularly when grazed in combination with stockpiled tall fescue, has the potential to keep cattle producers viable in a time of volatile commodity markets. Lawrence and Strohbehn (1999) reported that harvested forages represent the largest non-pasture-related feed cost in a cow-calf operation, and Poore et al. (2000) reported that strip-grazing stockpiled tall fescue may represent a 40% reduction in feed costs for yearling females when compared with harvesting that same fall growth as hay. Hence, developing a production strategy that minimizes baled forages by combining the use of corn-stalk residue and stockpiled forage would reduce harvested forage needs and their associated costs. Within the present experiment, this treatment combination resulted in 43 fewer days of harvested hay feeding. As importantly, this nutritional delivery strategy did not compromise cow or progeny performance.

Reproductive Efficiency

The tendency for a reduced proportion of DG-treated cows determined to be cycling at the beginning of ovulation synchronization was not expected. This is in contrast to other data from our laboratory where we reported a tendency for decreased postpartum interval in first-parity heifers fed DDGS as a primary dietary energy source from late gestation through early lactation (Gunn, 2013). In that experiment, and the current experiment, postpartum anestrus interval was not likely regulated by energy intake as diets were formulated to deliver similar daily amounts of NE_g. It is possible that excess dietary CP may be positively affecting postpartum interval and cyclicity, as CP greatly differed between treatments in both experiments. More specifically, in the current experiment, CON cows had an estimated daily CP intake during the prebreeding period that was 141% greater than the DG treatment. Bolze et al. (1985) reported a shorter postpartum interval for beef cows fed 150% of NRC CP requirements (NRC, 2000) when compared with cows fed 100% of CP requirements (NRC, 2000) during the last 112 d of gestation. However, before the availability of biofuel coproducts, overfeeding CP to lactating beef cows was typically not of concern because it was rarely economically feasible. Therefore, there is little information reported in the literature on the direct effects of excess postpartum CP supplementation on uterine involution and resumption of cyclicity. Therefore, current experiments are being conducted in our laboratory to elucidate the effects of excess dietary CP on reproductive function in beef cows.

Given the differences in CP consumption, it was not surprising that PUN concentrations were greater in CON- than DG-treated cows at the initiation of ovulation synchronization. This difference is of merit because Butler (1998) concluded in a review of dairy literature that blood urea nitrogen concentrations exceeding 19 to 20 mg/dL are associated with decreased fertility. Although average PUN concentrations in the current experiment did not exceed this threshold in either treatment, it should be noted that there were 4 CON-treated cows that did have PUN concentrations above 19 mg/dL at CIDR insertion, none of which were diagnosed as pregnant to TAI at initial pregnancy diagnosis. The reduction in fertility associated with elevated blood urea nitrogen concentration may be a result of hindered early embryonic development (Rhoads et al., 2006) resulting from impaired oocyte competence (Iwata et al., 2006). This might be the result of increased urea and ammonia exposure during the preovulatory period (Hammon et al., 2005). Alternatively, elevated PUN concentrations may decrease uterine pH (Elrod and Butler, 1993), which has the potential to alter sperm motility as proposed by Perry and Perry (2008) or result in a suboptimal uterine environment for embryo elongation and implantation.

The proportion of cows identified in estrus either before or at TAI, as indicated by a TPS of either 1 or 2, tended to be increased in the DG treatment. The cause of this observation cannot be established because follicular development and preovulatory hormone patterns were not studied. However, there was no relationship between the proportion of cows that were cycling before synchronization and the proportion of cows that had a TPS of 1 or 2 at TAI. Robinson et al. (2002) reported that both n-3 and n-6 PUFA, both of which are prevalent in

DDGS, decreased progesterone concentrations in cows during the early luteal phase, and n-3 PUFA decreased progesterone concentrations during the mid-luteal phase. Moreover, those authors found that n-3-supplemented cows had greater peak concentrations of estradiol and a greater area under the curve for estradiol during the follicular phase. Therefore, it is conceivable that cows fed DG may have had more estrogenic ovulatory follicles than CON, resulting in earlier onset of estrus and more cows with a TPS of 1 or 2 at TAI. This is noteworthy because preovulatory estradiol concentrations are thought to have a significant positive effect on pregnancy success (Bridges et al., 2010). Moreover, feeding PUFA may improve early embryo quality (Thangavelu et al., 2007; Cerri et al., 2009). Either scenario may explain the 8 percentage units increase in TAI pregnancy rates for DG cows when compared with CON. Although not significant, similar improvements in TAI conception rates for DDGS-fed cows have been observed in other studies performed by our group (Shee et al., 2012; Gunn, 2013) in which DDGS were fed as an energy source during early lactation.

More intriguing is the greater end of season pregnancy rate for DG when compared with CON-treated cows, particularly as DG cows were not supplemented DDGS during the natural service period of the breeding season. Although the reason for this difference is not clear, endophyte-infected tall fescue may be a factor. Research has demonstrated that grazing endophyte-infected tall fescue may induce suppressed first-service AI conception rates in heifers (Washburn et al., 1989) as well as suppressed calving rates in spring-calving cows (Gay et al., 1988; Washburn and Green, 1991). The reduction in fertility may be a result of reduced implantation rates, as suggested by Varney et al. (1987) in female rats fed an endophyte seed diet. It is generally accepted that negative effects of endophyte on performance are lesser when grazing fall growth when compared with summer grazing because endophyte is concentrated in the tall fescue stems and seed heads, which are less prevalent on fall regrowth. However, it should be noted that the hay fed during the post-AI phase of this experiment was also composed of endophyte-infected tall fescue, and therefore CON-treated cows did not experience a period of time during the breeding season in which they were exempt from endophyte. Furthermore, as bulls were removed on Julian d 35, it should be noted that DG-treated cows were only fed tall fescue hay for the last 15 d of the breeding season, whereas CON cows were fed hay for the duration of the post-TAI breeding season.

In addition to, or alternative to, endophyte effects on fertility, it is possible that there was a carry-over effect of prebreeding diet on fertility. Mihm and Bleach (2003) reported that it takes more than 30 d for ovarian follicles to develop from early antral stage to the recruitment phase of an ovarian follicular wave. Therefore, diets presented to cows before TAI could have affected oocyte quality in subsequent estrous cycles. Moreover, it is conceivable that such diets may have affected primary follicle development in addition to antral follicle development. The excess nitrogen in stockpiled forage grazed by CON-treated cows had the potential to negatively affect subsequent oocyte quality in CON cows that did not become pregnancy to TAI (Iwata et al., 2006). However, if excess nitrogen were responsible for a reduction in pregnancy success, it likely would have manifested itself in reduced TAI pregnancy rates for CON cows and also resulted in a reduced incidence of conception in DG-treated cows during the post-AI period when they were grazing stockpiles. Therefore, if a carry-over effect is responsible for differences in breeding-season pregnancy rates, we suggest that elevated dietary PUFA concentrations consumed by DG cows before TAI may have positively influenced subsequent oocyte quality in cows that did not become pregnant to TAI. However, further research needs to be conducted to validate such speculation.

Preweaning Progeny Performance

A tendency for increased birth BW of progeny born to DG-treated cows is likely due to the larger numerical proportion of bull calves born to DG-treated cows when compared with CON. Given the tendency for increased birth BW in progeny of DG-treated cows, it may have been expected that DG progeny were also heavier throughout the preweaning period and had a greater weaning BW. However, the spread in preweaning BW became larger with age, as indicated by greater preweaning ADG of DG progeny when compared with CON. This is similar to other preweaning data from our laboratory in which progeny of DDGS-fed, first-parity females tended to have increased preweaning ADG when compared with progeny of first-parity heifers fed a corn silage–based diet (Gunn, 2013). It should be reiterated in the current experiment that because of bunk design and DDGS delivery, it was impossible to restrict access of DG progeny to DDGS, and therefore, differences in progeny ADG may be partially a result of DDGS access. However, all DDGS were consumed before cows exited the bunk area, and therefore, calf access to DDGS should have been minimal. Moreover, as there was no interaction between treatment and incidence of calving at the initiation of the experiment for preweaning progeny growth parameters, we suggest that progeny growth was altered by way of lactational programming as proposed by Soberon and Van Amburgh (2012). These authors reported that increasing colostrum intake and neonatal energy intake increased subsequent lactation performance in dairy heifers. They also reported a strong positive correlation between preweaning ADG and lifetime milk production in dairy cows. Milk production and milk composition of the dam was not measured in this experiment. However, research in our laboratory has shown that even though total milk production was not altered, significant increases were noted in the unsaturated fatty acids and PUFA content of milk from cows fed DDGS as an energy source (Gunn, 2013; Shee et al., 2013). This is important because in nursing, preruminant calves, milk bypasses the nonfunctional rumen by closure of the esophageal groove. As a consequence, nutrients in the preruminant neonate are not subjected to rumen fermentation and alteration, and therefore nutrient absorption during this stage of development mimics intake. As such, it is conceivable that in addition to the amount of milk ingested, the fatty acid profile of the milk may be regulating neonatal growth-signaling pathways, particularly as dietary PUFA have been shown to increase circulating concentrations of IGF-1 in beef cattle (Robinson et al., 2002).

IMPLICATIONS

Adding a nutritional period of corn stover and supplementary DDGS to an existing stockpile grazing management system did not impair TAI pregnancy rates and improved breeding-season pregnancy rates in fall-calving cows. Moreover, use of corn stover and DDGS during early lactation resulted in greater preweaning progeny ADG and weaning weights. The potential exists to incorporate a period of corn residue grazing with DDGS supplementation into an existing grazing system of stockpiled tall fescue for fall-calving cows. Such a management practice could result in extension of the grazing season and reduced dependency on harvested forages during the winter, resulting in increased profit and sustained viability of beef producers in a volatile commodity market.

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