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PRODUCTION AND MANAGEMENT: *Original Research*

Performance of cows and summer-born calves and economics in semi-confined and confined beef systems

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ABSTRACT

Objectives: Cow and calf performance in a semi-confined cow-calf production system was compared with total confinement using summer-born calves.

Material and Methods: The experiment was conducted over 3 yr in eastern Nebraska (ENREC) and 2 yr in western Nebraska (PREC) in a randomized complete block design. Lactating, crossbred beef cows (n = 127 at ENREC; n = 56 at PREC) with summer-born calves were used from November to April. Treatments were (1) dry-lot feeding or (2) cornstalk grazing with supplementation. Dry-lot pairs were limit fed a crop residue and distillers–based diet to meet energy requirements of a lactating cow. A dried distillers grain–based pellet was supplemented to pairs on cornstalks at a rate of 2.4 kg of DM/pair daily. Dry-lot cow-calf pairs were limit fed 12.1 kg of DM/d throughout the trial.

Results and Discussion: At ENREC, cows wintered on cornstalks lost BW and had a 0.46-unit decrease in BCS ($P < 0.01$), whereas cows in the dry-lot gained BW and had a 0.24-unit increase in BCS. At PREC, BCS increased by 0.03 units for cows wintered in the dry-lot and decreased by 0.26 units for cows wintered on cornstalks ($P < 0.04$). At both locations, calves fed in a dry-lot had greater ADG and BW per day of age compared with calves offered cornstalk grazing with supplementation ($P \leq 0.03$).

Implications and Applications: A partial budget suggests that lower winter production inputs compensate for reduced performance of calves when cow-calf pairs are wintered on cornstalks, making residue grazing a viable option in partial confinement systems.

Key words: alternative systems, distillers supplementation, limit feeding, limited perennial forage, residue grazing

INTRODUCTION

Greater animal protein demand is anticipated to result from rapid population growth in developing countries and changing socio-demographics, such as increasing per capita incomes (Henchion et al., 2017). However, in the last 15 yr, substantial grassland has been converted to crop ground. Wright and Wimberly (2013) analyzed grassland conversion in the Western Corn Belt from 2006 to 2011 using satellite imagery that mapped agricultural land cover. Overall, the Western Corn Belt experienced a net decline of 530,000 ha of grass-dominated land cover, with annual conversion rates averaging between 1 and 5.4%.

Reduced land availability for grazing and forage production and subsequently greater production costs have encouraged many cow-calf producers to seek alternative production systems. Areas that are challenged by limited traditional forage resources commonly have greater grain crop production, resulting in greater availability of crop residue and by-products, particularly from ethanol production (Klopfenstein et al., 2008; Zulauf, 2016). Research has shown that dry-lot management of cows is a viable alternative to traditional pasture cow-calf production systems (Loerch, 1996; Jenkins et al., 2015; Warner et al., 2015a), especially using low quality residues and energy-dense by-products. A simulated economic analysis of an alternative production system suggests that using corn residue grazing as a component of a semi-confined cow-calf production system could reduce production costs of total confinement and provide a competitive alternative to traditional pasture cow-calf production (Warner et al., 2015b).

Research has indicated that nonlactating, gestating spring-calving cows maintain BW and BCS while grazing corn residue (Warner et al., 2011). However, minimal research is available on the performance of late-summer-

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born cow-calf pairs grazing corn residue. Therefore, the objective of the current experiment was to evaluate cow and calf performance in a semi-confined cow-calf production system compared with total confinement using summer-born calves.

MATERIALS AND METHODS

All facilities and management procedures used in this experiment were approved by the University of Nebraska–Lincoln Institutional Animal Care and Use Committee. This experiment was conducted over 3 yr at the Eastern Nebraska Research and Extension Center (**ENREC**) near Mead, Nebraska, and 2 yr at the Panhandle Research and Extension Center (**PREC**) at Scottsbluff, Nebraska, due to snow cover that negated stalk grazing in western Nebraska the first year. Lactating, composite (Red Angus × Red Poll × Tarentaise × South Devon × Devon) beef cows (n = 127 at ENREC; n = 56 at PREC) with summer-born calves were used in a randomized complete block design with 2 treatments. In yr 1, cow-calf pairs were blocked by cow BW in 4 blocks at ENREC, stratified by calf age, and assigned randomly within strata to 1 of 2 winter cow-calf production treatments with 4 replications (pens or paddocks) per treatment per year. In yr 2, cow-calf pairs were also blocked by cow BW in 2 blocks at PREC, stratified by calf age, and assigned randomly within strata to 1 of 2 winter cow-calf production treatments with 2 replications per treatment per year. Treatments were (1) dry-lot feeding (**DL**) or (2) cornstalk grazing (**CS**). In the subsequent years, cows within location were assigned to the same treatments as were assigned in yr 1. To maintain herd size, cows culled between years were replaced with pregnant, multiparous cows sourced from the same supplier and herd of the original cows.

Before the beginning of the experiment, cows within location were managed in a common feedlot pen and limit fed a distillers grain and wheat straw or cornstalk–based diet from mid-April to mid-November each year. Approximately 1 mo before calving, cows were vaccinated against bovine rotavirus, bovine coronavirus, *Escherichia coli*, and *Clostridium perfringens* type C (ScourGuard 4KC, Zoetis, Florham Park, NJ).

Cows calved in a feedlot pen during the summer with mean calving dates of July 14 (ENREC) and July 15 (PREC). Following parturition, calf birth date, weight, and sex were recorded and bull calves were band castrated. At approximately 30 d of age, calves were vaccinated for the prevention of blackleg caused by *Clostridium chauvoei*, malignant edema caused by *Clostridium septicum*, black disease caused by *Clostridium novyi*, gas-gangrene caused by *Clostridium sordellii*, enterotoxemia and enteritis caused by *Clostridium perfringens* (types B, C, and D), and disease caused by *Histophilus somni* (Ultrabac 7, Zoetis) and were vaccinated against infectious bovine rhinotracheitis, bovine viral diarrhea (types 1 and 2), parainfluenza-3, bovine respiratory syncytial virus, and *Mannheimia haemolytica* type A1 (Bovi-Shield Gold One Shot, Zoetis). All calves were revaccinated at 70 d of age with Bovi-Shield Gold One Shot and Ultrabac 7. At approximately 210 d of age, all calves were revaccinated against infectious bovine rhinotracheitis, bovine viral diarrhea (types 1 and 2), parainfluenza-3, and bovine respiratory syncytial virus (Bovi-Shield Gold 5, Zoetis).

The trial was initiated at the beginning of cornstalk grazing on approximately November 11 and November 22 for ENREC and PREC, respectively (yr 1: November 6 at ENREC; yr 2: November 11 at ENREC and December 4 at PREC; yr 3: November 15 at ENREC and November 11 at PREC).

Cow-calf pairs assigned to the DL treatment remained in dry-lot pens (279 m^2). Each pen housed 6 or 7 pairs allotting each pair 40 to 46 m^2. The natural terrain around the pens provided some wind protection at PREC, and stacked hay bales were used to provide a windbreak at ENREC where natural terrain was not sufficient. Dry-lot pairs within location were program fed a limit-fed diet (Table 1) formulated to meet energy requirements for a lactating cow in early gestation based on the NRC model (NASEM, 2016). Feed was delivered as a TMR once daily in concrete fence-line feed bunks (0.9 m of linear space per cow-calf pair). Dry matter offered increased by 0.45 kg monthly throughout the experiment to account for increasing intake of the growing calves. In yr 1 and 2, the amount of DM offered ranged from 11.6 to 13.4 kg/d. During yr 1 and 2, cows fed in the dry-lot were gaining BW and BCS and were not at maintenance. To correct for the BW and BCS gain, the amount of DM offered to cows in the dry-lot was reduced to a range of 11.1 to 12.9 kg/d during yr 3.

Within location, cow-calf pairs assigned to the CS treatment were hauled to a harvested irrigated cornfield within 8 km of the confinement facility. Stocking rate for cow-calf pairs grazing corn residue was calculated using estimated daily residue intake (range of 12.7 to 14.5 kg of DM/d) for the cow-calf pair (Meyer et al., 2012 throughout the grazing period and assuming 3.6 kg (DM) of husk and leaf residue were available for consumption per 25.5 kg of corn grain yield (Watson et al., 2015). The amount of supplement needed to meet the energy requirements of a cow-calf pair grazing corn residue was calculated using estimated residue intake of a pair (Meyer et al., 2012) and estimated digestibility values of corn residue throughout the grazing period (Wilson et al., 2004). Cow-calf pairs grazing corn residue were supplemented daily in bunks (0.9 m of linear space per pair) with dried distillers grain–based cubes (Table 2) at a rate of approximately 2.4 kg (range of 1.7 to 3.2 kg) of DM per pair daily, increasing monthly to account for increased calf requirement and intake. The amount supplemented was initially targeted to provide an equivalent energy intake to that of the dry-lot pairs. However, in yr 3, supplementation to cows on cornstalks was held constant while the DM offered to cows in the dry-lot was reduced. If snow cover prevented grazing, additional

Table 1. Diets fed to cow-calf pairs from November to April by location and year[1]

	Yr 1	Yr 2		Yr 3	
Item	**ENREC**	**ENREC**	**PREC**	**ENREC**	**PREC**
Ingredient, % diet DM					
Modified distillers grains plus solubles[2]	55	55	—	55	—
Wet distillers grains plus solubles[2]	—	—	58	—	58
Cornstalks[3]	—	40	—	—	—
Wheat straw[3]	40	—	40	40	40
Supplement[4]	5	5	2	5	2
Calculated composition					
DM, %	62.4	59.9	47.0	62.4	47.0
CP, %	19.3	19.3	18.8	19.3	18.8
TDN, %	79.1	79.1	81.0	79.1	81.0

[1]Dry matter offered (range of 11.1 to 13.4 kg/d) increased monthly throughout the experiment. ENREC = Eastern Nebraska Research and Extension Center near Mead, Nebraska; PREC = Panhandle Research and Extension Center near Scottsbluff, Nebraska.

[2]Formulated using 108% TDN value.

[3]Formulated using 43% TDN value.

[4]Supplement included to provide in the diet 0.02% limestone, 0.00003% Co, 0.002% Cu, 0.16% Mn, 0.01% Zn, 0.00007% I, and vitamins A, D, E premix.

supplemental feed was fed to grazing pairs. In yr 2, approximately 77 kg (DM) of ammoniated cornstalks were fed per pair at ENREC.

The trial was completed when winter cornstalk grazing ended on approximately April 10 and April 9 for ENREC and PREC, respectively (yr 1: April 13 at ENREC; yr 2: April 12 at ENREC and April 14 at PREC; yr 3: April 8 at ENREC and April 4 at PREC). The completion of the cornstalk grazing period coincided with weaning of all calves. Cow BW and calf BW were recorded over 2 consecutive days at trial initiation and completion to determine changes in BW from November to April. A trained technician at each location evaluated BCS (Wagner et al., 1988; 1 = emaciated; 9 = obese) of cows at trial initiation and completion. Before being weighed at trial initiation, all cow-calf pairs on both treatments were limit fed a common diet for a minimum of 5 consecutive days to reduce weight variation due to gastrointestinal tract fill (Watson et al., 2013). At trial completion, cows and calves were separated and again limit fed a common diet in the feedlot, to ensure gut fill was similar for both treatments, for a minimum of 5 d before being weighed. Cattle were weighed in the morning on 2 consecutive days before feeding (water not withheld), and those 2 weights were averaged to achieve an initial and final BW, respectively.

Cows were exposed to Simmental × Angus bulls (1 bull:10 cows on average because 2 bulls were assigned to each paddock after trial initiation) beginning approximately September 25 and September 26 each year with a 73- and 74-d breeding season at ENREC and PREC, respectively. Cows received prebreeding vaccinations for protection against infectious bovine rhinotracheitis, bovine viral diarrhea (types 1 and 2), parainfluenza-3, and bovine respiratory syncytial virus (Bovi-Shield Gold FP5

Table 2. Supplement fed to cow-calf pairs grazing cornstalks[1]

Ingredient, % diet DM	**Value**
Dried distillers grains plus solubles	93.28
Limestone	6.23
Pelleting binder (urea formaldehyde polymer and calcium sulfate)	0.21
Vitamins A, D, E	0.11
Trace mineral[2]	0.17

[1]Supplemented on average at a rate of 2.4 kg (range of 1.7 to 3.2 kg) of DM/pair daily.

[2]Trace mineral: 0.4389% Cu, 3.1818% Mn, 2.1511% Zn, 0.0067% Co, 0.0152% I, 94.2064% limestone carrier.

VL5 HB, Zoetis; and Ultrabac 7, Zoetis). All bulls were examined for breeding soundness and approved by a licensed veterinarian before the breeding season. Approximately 135 d after bull removal, blood samples were collected and tested for the presence of pregnancy-specific protein B to determine cow pregnancy status (BioPRYN; BioTracking Inc., Moscow, ID).

In vitro analysis of corn residue collected from each location was conducted to determine residue quality. Within location, fields were divided into 6 replications for sampling. This was done before harvest before the field was divided into paddocks for grazing. Ten consecutive whole corn plant samples harvested above the anchor root were collected from the 6 sampling sites just before grain harvest. Plant samples were separated into individual plant components (husk, leaf blade, and leaf sheath). Plant components were then composited within replication and ground through a 1-mm screen using a Wiley Mill (Thomas Scientific, Swedesboro, NJ). Each location was analyzed separately. Composite samples were then analyzed for in vitro OM digestibility in 2 runs using the Tilley and Terry (1963) method modified by the inclusion of 1 g of urea/mL of buffer (Weiss, 1994). A set of forage (grass and corn residue) standards with established in vivo values were included in each run to develop regression equations that allowed for the comparison between runs (Geisert, 2007). Triplicate samples from each plant fraction and standard were weighed into 100-mL in vitro tubes. Rumen fluid was collected from 2 donor steers fed a 30% concentrate diet. McDougall's buffer was mixed with rumen fluid to form inoculum, which was added to each tube. In vitro tubes were then incubated in a 39°C water bath for 48 h and swirled every 12 h. Following 48 h of incubation, fermentation was ceased by adding 5 mL of 20% hydrochloric acid and 3 mL of 5% pepsin to each tube. Tubes remained in the water bath for an additional 24 h and were then frozen immediately following removal. Contents from each tube were filtered through Whatman 541 filter paper, rinsed with distilled water, and dried in a 100°C oven for 12 h to determine DM. Filters were then placed in a muffle furnace at 600°C for 6 h to determine ash and OM (AOAC International, 1999; method 4.1.10). Digestible organic matter (**DOM**) was calculated by multiplying the in vitro OM digestibility and percent OM of the original residue sample.

Statistical Analysis

Data from the 2 locations (ENREC and PREC) were analyzed separately using the MIXED procedures of SAS (SAS Institute Inc., Cary, NC). Performance data were analyzed as a randomized complete block design. The model included pen or paddock as the experimental unit, cow-calf production system as the fixed effect, and block and year as random effects. Because the proportion of steer and heifer calves varied across replications, proportion of steers was included in the model as a covariate for all calf performance variables. For corn residue data, plant part was included as a fixed effect and year was a random effect in the model. Significance was declared at $P \leq 0.05$.

Economic Analysis

A partial budget was conducted retrospectively to economically compare wintering systems for cow-calf pairs within location. Economic assumptions were applied to each treatment with respect to days spent in each treatment. Treatment differences in expenses and income were entered into a partial budget Microsoft Excel (Microsoft, Redmond, WA) spreadsheet (Tigner, 2015) for both ENREC and PREC.

Cash corn prices were collected from Johanns (2017) to determine a 10-yr (2007–2016) average corn price of \$4.59/25.4 kg. The cost of distillers grains was calculated as 100% the value of corn on a DM basis because price is variable but over a 10-yr period averages close to corn. For the diet fed to DL cow-calf pairs, base price for baled crop residue was \$50 per 907 kg. An additional \$15 per 907 kg was charged to crop residue to account for grinding cost as well as a 10% shrink. Total diet cost was calculated on a DM basis for all feeds. Daily feed cost was calculated by multiplying diet cost by DMI for DL cow-calf pairs within location. Feedlot yardage was modified from Jensen and Mark (2010) and set at \$0.50 per pair per day with regard to increased maintenance from a nursing calf.

A freight expense for delivery of dry distillers grain to PREC was charged at \$2.80 per loaded kilometer (381 km). For CS cow-calf pairs, daily supplementation cost was calculated as the price of distillers grain multiplied by supplementation rate (2.4 kg per pair). Due to differences in regional availability of corn residue, leased acres for corn residue grazing were priced at \$12/0.41 ha and \$17/0.41 ha for ENREC and PREC, respectively, which corresponded to \$0.20 (ENREC) and \$0.30 (PREC) per pair daily. Grazing yardage expenses associated with animal care, fencing, and supplementing was charged at \$0.20 per cow-calf pair per day. At ENREC, cows that had been wintered on cornstalks were fed an additional 1.6 kg of feed for 75 d after weaning to compensate for BW and body condition losses incurred throughout the winter grazing period. Therefore, an additional feed cost was charged to CS cows at ENREC. The cost of additional feed was determined by multiplying the total amount fed over 75 d by the diet cost. Calf prices were collected from Schulz (2017) to determine 10-yr average prices received for weaned calves. To account for the lighter weaning weight of CS calves observed at both locations, a price slide of \$17.23/45 kg was used to determine the price received for weaned calves. The price slide was based on a regression of a 10-yr average price of steer and heifer calves weighing 226 to 272 kg and a 10-yr average price of steer and heifer calves weighing 272 to 318 kg.

RESULTS AND DISCUSSION

Cow-calf pairs grazed corn residue at ENREC for approximately 151 d (November 11 to April 10). At PREC, the grazing period was approximately 139 d (November 22 to April 9). Dry-lot cow-calf pairs consumed 12.3 kg of DM/d (ENREC) or 11.9 kg of DM/d (PREC) on average throughout the trial.

Cow performance is presented in Table 3. Initial cow BW and BCS were similar between treatments at both locations ($P \geq 0.50$). Cows that were managed in the dry-lot at ENREC had greater ending BW and BCS compared with cows grazing cornstalks ($P < 0.01$). Cows wintered on cornstalks at ENREC lost BW (33 kg) and had a 0.46-unit decrease in BCS, whereas cows in the dry-lot gained BW (40 kg) and had a 0.24-unit increase in BCS. At PREC, a significant difference was observed between treatments for cow BCS change ($P = 0.04$). Body condition score increased by 0.03 units for cows wintered in the dry-lot and decreased by 0.26 units for cows wintered on cornstalks. No significant differences ($P \geq 0.41$) were observed between treatments for any other cow performance variables at PREC.

Overall, the pregnancy rate was 90% of cows exposed, but the number of cows is too small to make a treatment comparison. Reproduction data required that cows had a treatment applied before the breeding season; therefore, treatment effect on pregnancy rate could only be measured for yr 2 and 3 at ENREC and yr 2 at PREC. There were 61 (CS = 33; DL = 28) and 19 (CS = 10; DL = 9) cows total from ENREC and PREC, respectively, that met these criteria. At ENREC, pregnancy rates were 98 and 83% for CS and DL cows, respectively. Pregnancy rates at PREC were 88 and 89% for CS and DL cows, respectively.

The performance of the cows grazing cornstalks is in agreement with Griffin et al. (2012), who reported that lactating, June-calving cows winter grazed on corn residue and fed a dried distillers grain–based supplement (0.45 kg per cow daily; 28% CP; prorated for delivery 3 d per week) lost BW and BCS. In the present experiment, the loss in BCS for cows wintered on cornstalks implies that the amount of energy provided was less than anticipated. An overestimation of the quality, residue intake, or both may explain the reduced performance of cows grazing cornstalks. More supplement might be needed to maintain BCS while grazing cornstalk residue. However, after weaning (April) the opportunity likely exists for a now dry cow with a low energy requirement to increase BCS on a low quality diet (4.5 kg of TDN/d) in the 4 mo before calving.

The increase in BCS and BW observed in cows managed in the dry-lot over the winter indicates that DL cows were overfed and not at maintenance. This increase in BW and BCS while program feeding was also noted by Loerch (1996) and Gunter et al. (2000). It is possible that cows become metabolically adapted during restricted intake and, therefore, have reduced energy requirements (Boardman et al., 2016). Furthermore, limit feeding confined cows may influence diet digestibility. Trubenbach et al. (2014) observed a 4.5-percentage unit increase in apparent OM digestibility when cows were restricted to 80% of energy maintenance requirements. Warner et al. (2011) reported that nonpregnant, nonlactating cows limit fed (1.3% of BW) a diet consisting of 41% wet distillers grains with solubles and 59% corn residue tended to have greater ADG compared with cows with ad libitum intake

Table 3. Performance of cows by cow-calf production system

	ENREC[1]				PREC[2]			
Item	CS[3]	DL[4]	SEM	*P*-value	CS	DL	SEM	*P*-value
Cow BW, kg								
Initial[5]	553	556	27	0.86	604	590	60	0.59
Ending[6]	520	596	22	<0.01	613	617	44	0.86
Cow BW change, kg	−33	40	9	<0.01	9	27	17	0.42
Cow BCS[7]								
Initial[5]	5.49	5.58	0.31	0.62	6.09	5.92	0.71	0.50
Ending[6]	5.03	5.82	0.18	<0.01	5.83	5.95	0.70	0.41
Cow BCS change	−0.46	0.24	0.20	<0.01	−0.26	0.03	0.08	0.04

[1]ENREC = 3 yr of data from the Eastern Nebraska Research and Extension Center near Mead, Nebraska.

[2]PREC = 2 yr of data from the Panhandle Research and Extension Center near Scottsbluff, Nebraska.

[3]CS = pairs wintered on cornstalks.

[4]DL = pairs wintered in dry-lot.

[5]Initial date = November 11 at ENREC and November 22 at PREC.

[6]Ending date = April 10 at ENREC and April 9 at PREC.

[7]BCS on a 1 (emaciated) to 9 (obese) scale (Wagner et al., 1988).

Table 4. Performance of calves by cow-calf production system

Item	ENREC[1]				PREC[2]			
	CS[3]	DL[4]	SEM	*P*-value	CS	DL	SEM	*P*-value
Initial age,[5] d	121	118	4	0.43	131	129	17	0.62
Calf BW, kg								
Initial[6]	150	142	4	0.08	144	144	13	0.97
Ending[7]	240	289	5	<0.01	233	270	15	<0.01
Calf BW change, kg	90	148	4	<0.01	96	127	11	0.04
Calf ADG, kg	0.60	0.98	0.03	<0.01	0.70	0.93	0.06	0.03
BW/d of age,[8] kg	0.88	1.08	0.03	<0.01	0.89	1.03	0.06	0.02

[1]ENREC = 3 yr of data from the Eastern Nebraska Research and Extension Center near Mead, Nebraska.

[2]PREC = 2 yr of data from the Panhandle Research and Extension Center near Scottsbluff, Nebraska.

[3]CS = pairs wintered on cornstalks.

[4]DL = pairs wintered in dry-lot.

[5]Initial age = age at initiation of cornstalk grazing period.

[6]Initial date = November 11 at ENREC and November 22 at PREC.

[7]Ending date = April 10 at ENREC and April 9 at PREC.

[8]Weight per day of age at collection of weights following weaning.

of a mixture of bromegrass hay, corn residue, and alfalfa haylage. Jenkins et al. (2015) also reported an increase in BCS in gestating cows limit fed (1.4–1.7% BW) diets containing wheat straw and up to 65% wet distillers grains with solubles and sugar beet pulp (DM basis). These data suggest that the energy provided to cows in limit-fed systems may be underestimated or the energy required by confined cows is overestimated. This is difficult to adjust because the NRC model (NASEM, 2016) does not predict this outcome for the cow limit fed a nutrient-dense diet. However, Shike et al. (2009) reported maintaining BCS when limit feeding (1.7% BW) confined, lactating cows diets containing up to 75% dried distillers grains or wet corn gluten feed. Furthermore, we do not know the separate intakes of the cows and calves in either the dry-lot pairs or the stalk-grazing pairs, and the NRC models do not have requirements for pairs. Therefore, we cannot realistically estimate the efficiency of use of energy by either the cows or the calves.

Performance of calves is presented in Table 4. Calves at PREC were approximately 10 d older than calves at ENREC at the onset of the cornstalk grazing period. Similar cow-calf production effects were observed at both locations. Initial calf BW was not significantly different between treatments ($P \geq 0.08$). Calves wintered in the dry-lot had greater ending BW and BW change compared with calves grazing cornstalks ($P \leq 0.04$). Likewise, calves wintered in the dry-lot had greater ADG and BW per day of age compared with calves grazed on cornstalks ($P \leq 0.03$). The observations of this experiment are in agreement with those of Griffin et al. (2012), who also reported similar weaning weights and ADG for June calves grazed on cornstalks and weaned in April.

Numerically, the cows grazing cornstalks at PREC gained 9 kg, whereas the cows at ENREC lost 33 kg. Calves at PREC gained 0.7 kg/d, whereas those at ENREC gained 0.6 kg/d. In vitro analysis of the corn residue from each location was conducted to determine whether residue quality was related to the apparent differences in performance of the pairs grazing cornstalks. In vitro OM

Table 5. In vitro OM digestibility (IVOMD) and digestible OM (DOM) of corn plant components collected before grain harvest at ENREC[1] or PREC[2]

Item	Plant component[3]				
	Husk	Leaf blade	Leaf sheath	SEM	*P*-value
ENREC					
IVOMD, %	63.9[a]	45.8[b]	36.2[c]	1.3	<0.01
DOM,[4] %	61.4[a]	40.9[b]	33.4[c]	1.3	<0.01
PREC					
IVOMD, %	70.1[a]	62.6[b]	59.0[c]	2.1	<0.01
DOM,[4] %	67.0[a]	53.2[b]	53.1[b]	1.9	<0.01

[a–c]Means within a row with unique superscripts differ ($P < 0.05$).

[1]Eastern Nebraska Research and Extension Center.

[2]Panhandle Research and Extension Center.

[3]Samples were from hand-clipped whole corn plants divided into individual plant parts.

[4]Digestible OM (as a % of DM) calculated as OM content (%) × IVOMD (%).

digestibility and DOM of corn residue from ENREC and PREC are presented in Table 5. Assuming cattle consume residue (husk, leaf, and sheath) in the same proportion as it is produced on the plant (18% husk, 55% leaf, and 27% sheath; Gardine et al., 2017), DOM of consumed residue in the current experiment was 42.6 and 55.7% at ENREC and PREC, respectively. The 13.1% unit difference in DOM of corn residue observed between locations may explain variation in cow-calf performance.

A partial budget of incorporating winter cornstalk grazing into a semi-confined cow-calf production system indicated that grazing cow-calf pairs on corn residue was a more profitable system compared with year-round confinement. Sulc and Tracy (2007) also suggested integrating crops and livestock, particularly through residue grazing, improves economic sustainability for crop and livestock operations. A partial budget using data from ENREC (Table 6) suggested that winter grazing cow-calf pairs on corn residue resulted in a greater net profit of $112 per pair compared with feeding cow-calf pairs in the dry-lot over the winter. At ENREC, grazing cornstalks saved the system $216 per pair (additional cost − reduced cost). Because the calves wintered on cornstalks at ENREC were 49 kg lighter at weaning compared with calves wintered in the dry-lot, income was decreased by $104 per calf. The dry-lot cows gained weight and were likely overfed, which would increase the cost slightly. Cows that grazed stalks lost weight and were fed extra feed during the subsequent dry-lot phase before calving at a cost of $20 (Table 6). Cows were at similar BW before calving. A partial budget for PREC (Table 7) indicated that grazing pairs on cornstalks over the winter resulted in $92 greater net profit per pair compared with cow-calf pairs fed in the dry-lot. By grazing cow-calf pairs on cornstalks at PREC, $175 (additional cost − reduced cost) was saved compared with feeding in the dry-lot. The 37-kg-lighter weaning weight of calves wintered on cornstalks compared with calves fed in the dry-lot resulted in $83 less income per calf. Overall, the decrease in production cost more than offset reduced performance of calves wintered on cornstalks at both locations.

APPLICATIONS

This experiment evaluated performance and economics of cow-calf pairs maintained in a semi-confined cow-calf production system compared with total confinement using summer-born calves. In this particular experiment, cows grazing corn residue in the winter had similar or reduced BW and BCS compared with cows fed a complete diet throughout the winter in the dry-lot. Nursing-calf ADG was greater for calves wintered in the dry-lot than for calves grazing cornstalk residue. Winter production costs were lower for residue grazing cow-calf pairs than for confined cow-calf pairs, making the residue grazing pairs more profitable than the total confinement pairs. These data

Table 6. Partial budget analysis of grazing cow-calf pairs on corn residue or feeding in a dry-lot at ENREC[1]

Increased costs of system	Amount, $
Graze corn residue	
Corn residue land rental [$12/0.41 ha ($0.20/pair daily)]	30
Supplement[2]	78
Cattle and fence care (yardage; $0.20/pair daily)	30
Postweaning feed[3]	20
Total costs	158
Revenue[4]	809
Change in net income	+112
Dry-lot	
Total mixed diet (harvested crop residue and distillers grains)[2,5]	298
Feedlot yardage ($0.50/pair daily)	76
Total costs	374
Revenue[4]	913

[1]Partial budget evaluated change in costs and revenue due to grazing cow-calf pairs on corn residue throughout the winter months compared with feeding in a dry-lot at the Eastern Nebraska Research and Extension Center (ENREC). All values are shown per cow-calf pair.

[2]Distillers grains priced at 100% the price of corn at $4.59/25.4 kg (Johanns, 2017).

[3]Cost to feed an additional 1.6 kg (DM) for 75 d after weaning to cows to compensate for BW and BCS losses incurred throughout the winter grazing period.

[4]Calf price was determined through a regression of 10-yr-average prices for calves weighing 226 to 272 kg (corn residue treatment) and 272 to 318 kg (dry-lot treatment; Schulz, 2017).

[5]Base crop residue priced at $50/907 kg plus $15/907 kg for grinding and 10% shrink.

Table 7. Partial budget analysis of grazing cow-calf pairs on corn residue or feeding in a dry-lot at PREC[1]

Increased costs of system	Amount, $
Graze corn residue	
Corn residue land rental [$17/0.41 ha ($0.30/pair daily)]	42
Supplement[2]	89
Cattle and fence care (yardage; $0.20/pair daily)	28
Total costs	159
Revenue[3]	792
Change in net income	+92
Dry-lot	
Total mixed diet (harvested crop residue and distillers grains)[2,4]	264
Feedlot yardage ($0.50/pair daily)	70
Total costs	334
Revenue[3]	875

[1]Partial budget evaluated change in costs and revenue due to grazing cow-calf pairs on corn residue throughout the winter months compared with feeding in a dry-lot at the Panhandle Research and Extension Center (PREC). All values are shown per cow-calf pair.

[2]Distillers grains priced at 100% the price of corn at $4.59/25.4 kg (Johanns, 2017). Dry distillers grains used to supplement grazing cattle had an additional charge of $2.80 per loaded kilometer for delivery (381 km).

[3]Calf price was determined through a regression of 10-yr-average prices for calves weighing 226 to 272 kg (corn residue treatment) and 272 to 318 kg (dry-lot treatment; Schulz, 2017).

[4]Base crop residue priced at $50/907 kg plus $15/907 kg for grinding and 10% shrink.

suggest that wintering pairs on cornstalk residue with supplement results in more net profit than maintaining pairs in confinement, even though confined calves weighed more at weaning than residue grazing calves, and that partial confinement with residue grazing is a viable system for beef cattle where perennial forages are limited.

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