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Evaluation of Berseem Clover in Diets of Ruminants Consuming Corn Crop Residues^{1,2,3}

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ABSTRACT: Berseem clover hay was compared to alfalfa hay provided at 0, 25, and 50% of the diet DM in mixtures with corn crop residues to wether lambs. Berseem clover hay had lower ($P < .05$) concentrations of NDF, ADF, and CP than alfalfa hay. The digestibility of DM, DMI, and N balance did not differ ($P > .05$) between diets containing alfalfa hay or berseem clover hay. To evaluate stockpiled berseem clover as a supplement for grazed corn crop residues, berseem clover and oats were incorporated into a corn-corn-oat/berseem clover crop rotation for 3 yr in replicated 6.1-ha fields. Two cuttings of oat-berseem clover hay were harvested each summer before forage was stockpiled for winter grazing. After corn grain harvest, multiparous and primiparous crossbred cows in midgestation were allotted to each field at 1.01 ha/cow to strip-graze corn crop residues with or without stockpiled berseem clover or allocated to replicated drylots for 98 to 140 d. Each group was offered alfalfa-grass hay as large bales to maintain a mean body condition score of 5 on a 9-point

scale. Mean rates of total and digestible OM disappearance from grazed and ungrazed field areas of berseem clover and corn crop residues did not differ over the 3 yr. In vitro organic matter disappearance (IVOMD) tended to decrease more rapidly ($P = .13$) and NDF and ADF concentrations increased more rapidly ($P < .05$) in berseem clover than in corn crop residues. Seasonal BW change did not differ ($P > .05$) between winter management systems in any year, and seasonal body condition score changes did not differ ($P > .05$) between cows grazing corn crop residues and berseem clover and those maintained in a drylot in yr 2 and 3. Cows grazing corn crop residues with or without berseem clover required less ($P < .05$) hay than those maintained in drylot. Although the effects of berseem clover hay supplementation on the intake and digestibility of corn crop residues do not differ from alfalfa hay, the nutritional value of stockpiled berseem clover decreases rapidly during winter, limiting its value as a standing supplement for corn crop residues in late winter.

Key Words: Crop Residues, Grazing, *Trifolium alexandrinum*

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Introduction

Corn crop residues are an economical feed source for beef cow-calf production in the midwestern United States (Klopfenstein et al., 1987), but supplementation

may be required for their efficient use (Fernandez-Rivera and Klopfenstein, 1989). Protein supplementation of low-quality forages has increased DM intake (Caton et al., 1988; DelCurto et al., 1990a), DM digestibility (Wiedmeir et al., 1983; Caton et al., 1988), BW gain (Caton et al., 1988; DelCurto et al., 1990a), reproductive efficiency, and calf weaning weights (Clanton, 1982). Most investigations of the effects of protein supplementation have been conducted using concentrated protein sources, such as soybean meal, cottonseed meal, corn gluten meal, and wheat middlings (McCollum and Galyean, 1985; Adamu et al., 1988; Heldt et al., 1998). When used to supplement low-quality roughages, alfalfa hay and soybean meal-based supplements supported similar levels of animal performance if fed in isonitrogenous diets (Clanton, 1982; DelCurto et al., 1990b).

Grazing stockpiled hay crop forages reduces the amounts of stored forages required to maintain cows at a condition score of 5 on a 9-point scale in winter (Hitz and Russell, 1998). Decreased OM digestibility and increased ADIN concentration resulting from

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weathering of stockpiled grass-legume forages have occurred during winter (Hitz and Russell, 1998) and may limit the value of these forages as supplements for corn crop residues.

Berseem clover is an annual legume used in crop rotations (Evers et al., 1993) and contains high concentrations of digestible DM and CP (Hattab and Harb, 1994). However, the value of berseem clover in a system of winter stockpiled grazing has not been determined.

Therefore, our objectives were to compare intake and digestibility of mixtures of berseem clover and alfalfa hays with corn crop residues in lambs and to determine the efficacy of stockpiled berseem clover as a supplement for gestating beef cows grazing corn crop residues.

Materials and Methods

Digestion Experiment

The third cutting of alfalfa (*Medicago sativa* L.) and berseem clover (*Trifolium alexandrinum*, cv. BigBee) forages were harvested in early September at first flower, field-cured, baled as small rectangular bales (27 kg, $1.15 \times .35 \times .40$ m), and stored in a barn. Although earlier cuttings from fields planted with oats and berseem clover seemed to have a high proportion of oat forage, the third cutting of hay from these fields seemed to contain almost entirely berseem clover. Following grain harvest, crop residues from corn (*Zea mays* L.) were baled and stored outside on the ground. Prior to feeding, alfalfa and berseem clover hays were ground through a wood chipper with a 2.5-cm screen, and the baled corn crop residues were ground through a tub grinder with a 5-cm screen.

Six 8-mo-old wether lambs (mean weight, 48 kg) were blocked by weight into two groups and used in a digestion trial with a dual 3×3 Latin square design. Each period consisted of a 10-d adaptation and a 5-d collection phase. Sheep were housed in individual metabolism cages within a temperature-controlled barn (24°C, continual light). Experimental diets consisted of corn stalks with 0, 25, or 50% of the diet DM from alfalfa or berseem clover hay. Hay species was assigned to square. Animals were fed at 0800 and 2000 daily at 10% above ad libitum intake of the previous day. Animal procedures were conducted within the guidelines set forth by the Iowa State University Animal Use and Care Committee.

During the collection phase, feed and orts were collected and composited at 1800 on d 8 through 13 of each period. Feces and urine were collected at 1800 on each day of the collection period, weighed, subsampled at 10% of total, composited over a 5-d period, and frozen. Total feces were collected in fecal pans. Urine was collected in plastic pans containing 10 mL of 50% sulfuric acid and 10 mL of toluene. Feces, orts, and feed were divided into two subsamples before analysis. One sample was analyzed for N as a fresh sample, and the other sample was oven-dried at 60°C for 48 h and ground for later analysis.

Grazing Experiment

Fields. A 24.4-ha area was divided on the basis of soil type into two 12.2-ha blocks and each block was subdivided into two 6.1-ha fields. For 3 yr, berseem clover (*Trifolium alexandrinum*, cv. BigBee, 24.5 kg/ha) was seeded with oats (*Avena sativa*, cv. Frank, 107.8 kg/ha) into a 2.02-ha area that was rotated annually within one of the 6.1-ha fields in each block in a corn-corn-oat/berseem clover crop rotation. Corn was seeded into the remaining areas of each block. The same fields were used each year of the experiment. Hay was harvested from the oat-berseem clover forage in two cuttings. Forage regrowth after the second hay harvest was primarily berseem clover and was allowed to accumulate as stockpiled forage beginning on July 9 (yr 1), August 8 (yr 2), and August 15 (yr 3). After corn grain harvest, the four 6.1-ha fields were each divided into four paddocks with electric fences that were incrementally removed to allow strip-grazing. One 6.1-ha field in each block contained stockpiled berseem clover and corn crop residues at a ratio of 1:2 on a land area basis. These fields were fenced to allow for simultaneous grazing of clover and corn residues.

Animals. Thirty-eight (33 multiparous and 5 primiparous, yr 1), 36 (28 multiparous and 8 primiparous, yr 2), and 36 (30 multiparous and 6 primiparous, yr 3) Charolais \times Angus \times Simmental cows (mean BW, 637 kg; mean body condition score, 5.2) in midgestation were blocked on the basis of age, weight, and body condition score and allotted to one of six groups. Four groups grazed corn crop residues (stocking rate = .99 cows/ha) with or without stockpiled berseem clover and two groups were placed in two drylot pens. Grazing was initiated on November 3, 1994, November 9, 1995, and December 4, 1996, and continued for 140, 114, and 98 d in yr 1, 2, and 3, respectively. Ungrazed paddocks were opened at 28-d intervals in yr 1 and 2 and at 21-d intervals in yr 3. Supplemental alfalfa-grass hay was offered as barn-stored large, round bales to all cows to maintain a body condition score of 5 on a 9-point scale (Neumann and Lusby, 1986) or when weather conditions prevented grazing. Cows had ad libitum access to a mineral-vitamin mixture containing 45% dicalcium phosphate, 50% salt, 3% trace mineral premix (10% Fe, 1.5% Cu, 12% Zn, 8% Mn, .10% Co, and .20% I), and 2% vitamin A premix (3,000 IU of vitamin A/kg of DM).

Forage Mass and Composition Determination. Samples of stockpiled berseem clover were taken monthly during the grazing season by hand-clipping a .25-m² area in three locations within each grazed and ungrazed paddock. Corn crop residues were sampled by hand from a 4-m² area in two locations within each grazed and ungrazed paddock. All corn crop residue material was sampled except the bottom 20 cm of stalk to exclude material not normally grazed. At the end of grazing, samples were collected from four 4-m² (crop residue) and four .25-m² (berseem clover) grazing exclosures. Forage samples were weighed to determine yield. Corn

crop residues samples were ground with a hammer mill to pass through a 2.5-cm screen and subsampled. In January and March, barn-stored bales of alfalfa-grass hay were core-sampled at four locations around the bale (Brasche and Russell, 1988). Samples of stockpiled berseem clover, corn crop residues, and alfalfa-grass hay were dried at 60°C for 48 h and ground in preparation for further analysis.

Cow Weight, Condition Score, and Hay Feeding. Cows were weighed unshrunk at the initiation and termination of grazing after 2 d of ad libitum access to alfalfa-grass hay to equalize gut fill. Cows were also weighed unshrunk at 0800 monthly during the experiment. Cows were scored for body condition on a 9-point scale (Neumann and Lusby, 1986) by two individuals at 14-d intervals. Amounts of hay offered to all cows were recorded at each feeding and adjusted for DM concentration of samples collected in January and March.

Chemical Analyses

Dried samples of forages and feces from the digestion experiment and dried samples of forage from grazed paddocks and ungrazed exclosures from the grazing experiment were ground with a Wiley mill to pass through a 1-mm screen. Ash concentrations of all forage and fecal samples were determined after combustion in a preheated muffle furnace at 600°C for 2 h (AOAC, 1980). Because of the variable concentrations of ash caused by soil contamination of samples in the grazing experiment, concentrations of all other components of forages collected from fields in the grazing experiment were expressed as percentages of OM. Crude protein concentrations of forages from the digestion and grazing experiments and frozen feces and urine from the digestion experiment were determined with the Kjeldahl procedure (AOAC, 1980). Forage and fecal samples from the digestion experiment and forage samples from the grazing experiment were analyzed sequentially for NDF (Van Soest and Robertson, 1979) and ADF (Goering and Van Soest, 1970). Acid detergent insoluble nitrogen concentration of the forages from the grazing experiment was determined according to Goering and Van Soest (1970). In vitro dry matter disappearance of forages from grazed and ungrazed paddocks of the grazing experiment was determined with the procedure of Tilley and Terry (1963), as modified by Marten and Barnes (1980) with filtration on filter paper. Ruminant ingesta from an alfalfa-fed, ruminally fistulated steer was hand-collected and strained through four layers of cheesecloth to provide inocula for IVDMD determination. Samples were anaerobically incubated for 48 h in 50-mL centrifuge tubes fitted with Bunsen valves and for 24 h after addition of 1 mL of 6 N HCl and pepsin solution. In vitro OM disappearance (**IVOMD**) of forages was determined as the weight loss from combustion of filter papers containing undigested residues and blanks in a preheated muffle furnace at 600°C for 2 h (AOAC, 1980), expressed as a proportion of total OM.

Statistical Analyses

Composition of the forages fed in the digestion experiment were analyzed with ANOVA (SAS, 1982); differences between means of significant variables were tested with *t*-tests (Steel and Torrie, 1980). Intake and digestibility data from the digestion experiment were analyzed as a dual Latin square design with the GLM procedure of SAS (1982), with main effects of supplemental forage species, supplemental forage level, lamb, and period and the interaction of supplemental forage species and level with differences tested against the residual error. Differences between means with significant supplemental forage level effects or forage species \times level were tested with linear contrasts.

Differences in herbage mass and chemical composition of fields containing stockpiled berseem clover or corn crop residues at the initiation of winter grazing were analyzed with the GLM procedure (SAS, 1982) as a split-plot design with a model including the main effects of year, forage species, and block and interactions of year \times species, block \times year, block \times species, and block \times year \times species. Significance of species effects was tested against the year \times species interaction. Mean daily changes in herbage mass and chemical composition were determined from linear regression analysis (SAS, 1982) of the masses and compositions of herbage in grazed and nongrazed areas within each field at different sampling days over winter. Difference in the slopes of the daily changes in herbage mass and chemical composition of forages from grazed or nongrazed areas of stockpiled berseem clover or corn crop residues were analyzed with the GLM procedure (SAS, 1982) as a split-plot design with main effects of year, species, block, and grazing and two- and three-way interactions of year, species, and block and year, species, and grazing. Significance of species effects was tested against the year \times species interaction. Cow BW and condition score changes were analyzed as a complete block design within year using the GLM procedure of SAS (1982). Differences between means of significant variables were determined by *t*-tests. Because maintaining cow body condition score at 5 on a 9-point scale by supplementing alfalfa-grass hay as large round bales to small groups was difficult, the amounts of hay fed were analyzed by covariance using the GLM procedure (SAS, 1982) with the deviation of the final body condition score from 5 used as the covariate. Differences between least squares means of significant variables were determined with *t*-tests.

Results

Digestion Experiment

Both legume hays fed in the digestion experiment had lower ($P < .05$) NDF and ADF concentrations and higher ($P < .05$) CP concentrations than the corn crop residues (Table 1). At a comparable maturity, berseem

Table 1. Chemical composition of corn crop residues, alfalfa hay, and berseem clover hay fed to lamb in the digestion trial

Item	Forage			SEM ^a
	Corn crop residues	Alfalfa	Berseem clover	
DM	84.6 ^b	91.3 ^c	89.7 ^c	2.20
% of DM,				
NDF	72.7 ^b	43.5 ^c	32.0 ^d	.43
ADF	44.8 ^b	32.0 ^c	22.0 ^d	.62
CP	4.6 ^b	25.1 ^c	22.0 ^d	.55

^aStandard error of the mean, n = 3.

^{b,c,d}Differences between means with different superscripts are significant ($P < .05$).

clover hay had lower NDF ($P < .05$), ADF ($P < .05$), and CP ($P < .05$) concentrations than alfalfa hay.

Increasing the proportion of legume hays fed with corn crop residues increased (linear effects, $P < .01$) DM and N intake by lambs. There were no differences ($P > .10$) in the rates of these increases between forage species (Table 2). Increasing the proportions of legume hays fed with corn crop residues increased (linear effects, $P < .01$) the digestibilities of dietary DM, NDF, ADF, and CP and the nitrogen balance in lambs. The rates of increase for each percentage unit increase of legume hay DM in the diets were .31, .37, .22, and .81 percentage units for DM, NDF, ADF, and CP digestibilities and .13 g/d for nitrogen balance. The linearity of the effects of legume hay supplementation on intakes and digestibilities of dietary DM and its components imply that these effects were directly related to the change in hay proportion and not related to any associative feed effects. Similar to intake, effects of replacing corn crop residues with legume hays on nutrient digestibilities did not differ ($P > .10$) between the two forage species.

Grazing Experiment

Weather conditions varied considerably during the months of grazing (Table 3). High precipitation, mainly

as rain, occurred in the first and last month of grazing in yr 1 and in the second and last month of grazing in yr 3. In each year, higher temperatures were observed in the first and last month of grazing compared with the middle of each grazing season.

Over 3 yr, there were no differences ($P > .10$) in mean OM or IVOMD masses of corn crop residues or stockpiled berseem clover at the initiation of grazing (Table 4). Organic matter masses of corn crop residues at the initiation of grazing, however, were greater than those of stockpiled berseem clover in yr 1 and 2 and lower than those of stockpiled berseem clover in yr 3 (year \times species, $P < .01$). Likewise, IVOMD masses of corn crop residues at the initiation of grazing did not differ from those of stockpiled berseem clover in yr 1 and 2 but were less than stockpiled berseem clover in year 3 (year \times species, $P < .01$). Similar to initial OM and IVOMD masses, the mean rates of OM and IVOMD loss during the grazing season did not differ ($P > .10$) between species or in grazed and ungrazed areas over the 3 yr. However, even though the rates of loss of OM and IVOMD from corn crop residues were greater than from stockpiled berseem clover in yr 1, the rates of OM and IVOMD loss from corn crop residues were less than those of stockpiled berseem clover in yr 2 and 3 (year \times species, $P < .01$). The differences in loss rates in stockpiled berseem clover between years may have resulted

Table 2. Effect of hay species and proportion of hay fed with ground corn crop residues on dry matter intake and total diet digestion coefficients.

Item	Supplemental hay species (sp) and dietary proportion (p)						SEM ^a	Significance		
	Alfalfa hay			Berseem clover				sp	p ^b	sp \times p
	0	25	50	0	25	50				
DMI, g/d	371	480	691	350	454	678	23.6	.35	.01	.97
DMI, % BW	.7	1.0	1.4	.7	.9	1.4	.06	.56	.01	.91
Nitrogen intake, g/d	3.8	7.8	16.2	3.8	8.1	15.7	.32	.53	.01	.89
Digestion coefficients, %										
DM	40.8	48.9	55.3	40.6	53.7	56.8	2.90	.42	.01	.69
NDF	16.7	26.0	34.1	15.9	30.2	35.3	3.23	.58	.01	.72
ADF	17.9	25.4	30.2	14.5	23.6	25.0	2.23	.10	.01	.75
N	-12.1	25.4	31.7	-11.4	20.8	37.5	7.38	.61	.01	.89
N balance, g/d	-.64	2.3	5.6	-.44	1.9	6.1	.41	.52	.01	.76

^aStandard error of the mean, n = 3.

^bAll linear contrasts for level effects were significant ($P < .01$).

Table 3. Total monthly precipitation and average monthly temperature in each year during the grazing experiment

Year	Month					
	January	December	January	February	March	
	Total precipitation, cm/mo ^a					
1	4.5	1.9	1.0	.7	5.9	
2	3.5	1.5	3.0	.4	3.6	
3	2.2	10.1	1.4	2.8	4.8	
	Mean temperature, °C					
1	4.6	-3.6	-7.9	-3.3	3.1	
2	4.8	-.3	-8.7	-4.7	-.3	
3	-2.9	-1.2	-4.3	-.3	9.7	

^aTotal moisture as rain, snow, or sleet.

from sampling errors in yr 1 caused by leaf loss that occurred while attempting to elevate the berseem clover forage from the ground prior to initial sampling. In subsequent years, stockpiled berseem clover forage was left prone, and all herbage within the sampling square was collected regardless of whether the base of an individual plant was within the square. Although the mean effects of grazing on the rates of OM and IVOMD loss were not significant across species over the 3 yr, the rates of OM (species × grazing, $P = .08$) and IVOMD (species × grazing, $P < .01$) loss were greater in grazed than in ungrazed corn crop residues but did not differ in stockpiled berseem clover. Therefore, whereas weathering losses were 49.0 and 74.2% of the grazing losses of OM and IVOMD from corn crop residues, weathering losses were 105.8 and 105.6% of the grazing losses of OM and IVOMD from stockpiled berseem clover.

Over the 3 yr of the experiment, mean OM concentrations of corn crop residue and stockpiled berseem clover forage at the initiation of grazing did not differ ($P >$

.10; Table 5). However, whereas the initial OM concentrations did not differ between corn crop residues and stockpiled berseem clover in yr 1 and 3, corn crop residues had a higher initial OM concentration than stockpiled berseem clover in yr 2 (94.1 vs 88.6% of OM; year × species, $P < .01$). Corn crop residues had lower (46.4 vs 54.0% of OM; $P = .04$) mean concentrations of IVDOM and greater (77.5 vs 54.5% of OM, $P = .05$) mean concentrations of NDF than stockpiled berseem clover at the initiation of grazing. The differences between corn crop residues and stockpiled berseem clover in yr 1, 2, and 3 were 7.5, 10.5, and 4.7 percentage units for initial IVOMD concentration (species × year, $P < .01$) and 17.6, 33.8, and 17.5 percentage units for initial NDF concentration (species × year, $P < .01$). Because berseem clover was stockpiled for 117 d until November 3 and 90 d until November 9 in yr 1 and 2, respectively, the lesser differences in the initial IVOMD and NDF concentration between corn crop residues and berseem clover in yr 1 than in yr 2 likely resulted from differences in the lengths of berseem clover stockpiling. In yr 3, initiation

Table 4. Initial and daily changes in OM and in vitro OM disappearance (IVOMD) masses of corn crop residues and stockpiled berseem clover during winter grazing seasons

Year	Initial, kg/ha		Change, kg·ha ⁻¹ ·d ⁻¹				SEM ^a		Significance			
	Corn crop residues	Berseem clover	Corn crop residues		Berseem clover		Initial	Change	Initial forage species (sp)	Change		
			Grazed	Ungrazed ^b	Grazed	Ungrazed				sp	(g)	sp × g
OM												
1	5,943	5,310	-16.1	-11.4	3.2	1.9	183.2	1.22	.76	.57	.21	.08
2	5,312	4,651	-16.9	-2.6	-23.1	-22.8						
3	4,287	6,602	7.8	1.6	-25.2	-26.9						
IVOMD												
1	2,805	2,912	-10.4	-9.5	-6.7	-8.2	77.7	.37	.31	.31	.15	.01
2	2,662	2,815	-10.8	-4.2	-15.5	-15.2						
3	1,801	3,095	-2.0	-3.5	-15.7	-16.6						

^aStandard error of the mean, n = 4 for corn crop residues, n = 2 for stockpiled berseem clover.

^bUngrazed samples collected from ungrazed paddocks prior to grazing during the experiment and from grazing exclosures at the termination of grazing.

Table 5. Initial and daily changes in OM, in vitro OM disappearance (IVOMD), NDF, and ADF concentrations of corn crop residues and stockpiled berseem clover during winter grazing seasons

Year	Initial		Change, %/d				SEM ^a		Significance			
	Corn crop residues	Berseem clover	Corn crop residues		Berseem clover		Initial	Change	Initial forage species (sp)	Change		sp × g
			Grazed	Ungrazed ^b	Grazed	Ungrazed				sp	Grazed (g)	
OM, % of DM												
1	90.6	91.4	-.18	-.14	-.04	-.04	.31	.011	.48	.30	.35	.16
2	94.1	88.6	-.01	-.01	-.09	-.01						
3	92.8	92.6	-.26	-.21	-.08	-.21						
IVOMD, % of OM												
1	47.2	54.7	-.09	-.09	-.16	-.16	.44	.007	.04	.13	.07	.98
2	50.1	60.6	-.08	-.06	-.12	-.08						
3	42.0	46.9	-.11	-.09	-.12	-.12						
NDF, % of OM												
1	77.7	60.1	.02	-.01	.08	.06	.71	.020	.05	.03	.48	.54
2	77.2	43.4	.01	-.02	.11	.12						
3	77.6	60.1	0	-.02	.11	.11						
ADF, % of OM												
1	49.5	40.1	.07	.03	.11	.09	.61	.003	.25	.04	.01	.01
2	48.3	29.3	.05	.01	.12	.07						
3	46.4	47.3	.03	.01	.04	.06						

^aStandard error of the mean, n = 4 for corn crop residues, n = 2 for stockpiled berseem clover.

^bUngrazed samples collected from ungrazed paddocks prior to grazing during the experiment and from grazing exclosures at the termination of grazing.

of grazing was delayed until December 4, because of rain-delayed corn planting in the spring and a late grain harvest in fall. Therefore, although there were 111 d between the initiation of stockpiling and the initiation of grazing, the small differences in the initial concentrations of IVOMD in stockpiled berseem clover and corn crop residue in yr 3 likely resulted from weathering of the stockpiled berseem clover that occurred before the initiation of grazing. The mean ADF concentration at the initiation of grazing did not differ ($P > .10$) between species over the 3 yr. Similar to the NDF concentrations, however, differences in ADF concentrations of corn crop residues and stockpiled berseem clover were 9.4, 19.2, and -9 percentage units in yr 1, 2 and 3, respectively (year × species, $P < .01$).

The mean rate of change in OM concentration over the grazing season was $-.11$ percentage unit/d and did not differ ($P > .10$) between forage species over the 3 yr. However, even though there were no differences in the rates of decrease in OM concentration between forage species in yr 2 and 3, OM concentration decreased at a greater rate from corn crop residues than from stockpiled berseem clover in yr 1 ($-.16$ vs $-.04$ percentage unit/d; year × species, $P < .01$). This result implies greater soil contamination of the corn crop residues than of stockpiled berseem clover in yr 1. Over 3 yr, mean NDF ($.10$ vs 0 percentage unit/d; $P = .03$) and ADF ($.08$ vs $.03$ percentage unit/d; $P = .04$) concentrations of stockpiled berseem clover increased and mean IVOMD concentrations of stockpiled berseem clover tended ($-.13$ vs $-.09$ percentage unit/d; $P = .13$) to de-

crease at a greater rate than corn crop residues. Differences between corn crop residues and stockpiled berseem clover for the rates of increase in ADF concentration in yr 1 ($.05$ vs $.10$ percentage unit/d) and yr 2 ($.03$ vs $.09$ percentage unit/d) were large, but there was little difference in the rate of ADF change between corn crop residues and stockpiled berseem clover in yr 3 (species × year, $P < .01$). Similarly, differences in the rates of decrease in IVOMD concentration of corn crop residues and stockpiled berseem clover ($-.09$ vs $-.16$ percentage unit/d) in yr 1 were large, but there was little difference between the rates of change in IVOMD concentrations of the corn crop residues and stockpiled berseem clover in yr 2 and 3 (species × year, $P = .07$). The lack of differences in the rates of change in ADF and IVOMD in yr 3 may have been associated with weather damage that may have occurred to the stockpiled berseem clover before grazing was initiated. Over 3 yr, mean rates of change in OM concentration did not differ from grazed and ungrazed areas of the fields. However, the rates at which OM concentration decreased were greater from grazed than from ungrazed areas in yr 1 ($-.11$ vs $-.09$ percentage unit/d) and 2 ($-.05$ vs $-.1$ percentage unit/d; grazing × year, $P = .04$). Similar to OM, rates of change of NDF concentrations of forages did not differ ($P > .10$) from grazed and ungrazed areas of the fields over 3 yr. However, IVOMD concentration decreased ($-.11$ vs $-.10$ percentage unit/d; $P = .07$) and ADF concentration increased ($.07$ and $.05$ percentage unit/d; $P < .01$) at greater rates in forages from grazed than in those from ungrazed areas of the fields. Although the difference in the rates of decrease in

Table 6. Initial and daily changes in CP and ADIN concentrations of corn crop residues and stockpiled berseem clover during winter grazing seasons

Year	Initial		Change, %/d				SEM ^a		Initial forage species (sp)	Significance		
	Corn crop residues	Berseem clover	Corn crop residues		Berseem clover		Initial	Change		Change		
			Grazed	Ungrazed ^b	Grazed	Ungrazed			sp	Grazed (g)	sp × g	
	CP, % of OM											
1	5.2	14.1	.01	.01	.02	.02	.16	.004	.01	.60	.15	.51
2	4.4	17.3	0	0	-.04	0						
3	4.7	17.5	.01	.02	0	0						
ADIN, % of N												
1	24.2	16.9	.14	.06	.10	.08	1.97	.011	.26	.32	.18	.28
2	18.1	13.5	.04	.05	.06	.01						
3	17.7	18.4	.13	.10	-.01	.05						

^aStandard error of the mean, n = 4 for corn crop residues, n = 2 for stockpiled berseem clover.

^bUngrazed samples collected from ungrazed paddocks prior to grazing during the experiment and from grazing exclosures at the termination of grazing.

IVOMD concentration between forages from grazed and nongrazed field areas were large in yr 2 (-.10 vs -.07 percentage unit/d), the difference in these rates was small in yr 1 (-.13 vs -.13 percentage unit/d) and 3 (-.12 vs -.11 percentage unit/d; species × year, $P = .07$). Similarly, differences in the rates of increase in ADF concentration between forages from grazed and ungrazed field areas were large in yr 1 (.09 vs .06 percentage unit/d) and 2 (.09 vs .04 percentage unit/d) but small in yr 3 (.04 vs .04 percentage unit/d; species × year, $P < .01$). The greater decrease in the rate of IVOMD concentration and greater increase in ADF concentration imply that cows selectively grazed portions of the plants with lower ADF concentrations, particularly in yr 1 and 2, and greater IVOMD concentrations, particularly in yr 2. Because the difference in rates of increase in ADF concentration were greater in grazed and ungrazed areas of corn crop residues (.05 vs .03 percentage unit/d) than in stockpiled berseem clover (.09 vs .08 percentage unit/d; species × grazing, $P < .01$), cows seemed to be more selective when grazing corn crop residues than when grazing stockpiled berseem clover. The lack of differences in the rates of increase in NDF concentrations over 3 yr and the rates of decrease in the IVOMD concentration in yr 1 and 3 between forages in grazed and ungrazed field areas implies that the effects of weather damage on these forage components were nearly as great as the effects of grazing.

Corn crop residues had a lower ($P < .01$) mean CP concentration than stockpiled berseem clover at the initiation of grazing in each year (4.7 vs 16.3% of OM; Table 6). However, the mean proportion of nitrogen as ADIN at the initiation of grazing was 18.1% and did not differ ($P > .10$) between forage species over the 3 yr. The rates of change in CP concentrations of the forages over the experiments were low (mean change, .01 percentage unit/d) and did not differ ($P > .10$) be-

tween species or forages from grazed and ungrazed areas of the fields. The mean rate of change in the proportion of nitrogen as ADIN was .07 percentage unit/d and did not differ ($P > .10$) between species. However, there were few differences between corn crop residues and stockpiled berseem clover in the rate of increase in the proportion of nitrogen as ADIN in yr 1 (.10 vs .09 percentage unit/d) and 2 (.05 vs .04 percentage unit/d), but the mean of the increase in the proportion of N as ADIN was 5.7 times greater in corn crop residues than in stockpiled berseem clover in yr 3 (species × year, $P = .03$). The mean rate of change in the proportion of nitrogen as ADIN did not differ ($P > .10$) between forages from grazed and ungrazed areas of the fields, again implying that the effects of weathering on forage nutritive value were as great as those of grazing.

In yr 1 and 2, cows fed hay in drylots or grazing corn crop residues with stockpiled berseem clover had greater ($P < .05$) BW gains than cows grazing corn crop residues without stockpiled berseem clover during the first half of the grazing season (Table 7). However, there were no differences ($P > .05$) in BW changes of cows managed in the three winter management systems in the second half of the grazing season in yr 1 and 2 or over the entire grazing season in all years. Seemingly because of the delay in the initiation of grazing until after November with a high precipitation level in yr 3, BW gains of cows on all treatments in yr 3 (7.2 kg/cow) tended to be lower than BW gains of cows in yr 1 (78.4 kg/cow) and 2 (48.3 kg/cow) over the grazing season. In yr 3, BW changes of cows grazing corn crop residues with stockpiled berseem clover did not differ ($P > .05$) from those of cows fed crop residues without stockpiled berseem clover early in the grazing season, but BW gains of cows grazing corn crop residues with stockpiled berseem clover were less ($P < .05$) than those of cows grazing corn crop residues without stockpiled berseem clover late in the grazing season. Although hay supple-

Table 7. Body weight and condition score changes of cows maintained in drylots or grazing corn crop residues without or with stockpiled berseem clover

Season	Year and winter system												
	Yr 1											SEM	
	Drylot	Corn crop residues			Drylot	Corn crop residues			Drylot	Corn crop residues			
		Without berseem clover	With berseem clover	SEM ^a		Without berseem clover	With berseem clover	SEM		Without berseem clover	With berseem clover		SEM
Body weight change, kg/cow													
Early ^b	35.7 ^d	7.1 ^e	32.3 ^d	6.24	33.6 ^d	-4.3 ^e	41.4 ^d	10.61	23.6 ^d	-14.8 ^e	-4.8 ^e	6.75	
Late ^c	57.5	56.6	48.1	5.32	15.0	40.7	18.6	10.43	-13.9 ^d	23.4 ^e	8.0 ^f	2.28	
Total	93.2	63.6	78.4	8.54	48.6	36.4	60.0	8.57	9.8	8.6	3.2	6.87	
Body condition score change ^g													
Early	.4	-.2	.4	.35	.3 ^d	-.1 ^e	.8 ^f	.05	.3 ^d	-.1 ^e	0 ^e	.07	
Late	.7	.4	.6	.20	-.8 ^d	-.3 ^e	-.8 ^d	.14	-.3	-.2	-.4	.08	
Total	1.1 ^d	.2 ^e	.9 ^d	.20	-.5	-.4	0	.11	0	-.3	-.4	.20	

^aStandard error of the mean, n = 2.

^bEarly season was the first 70, 57, and 49 d of grazing in yr 1, 2, and 3.

^cLate season was the last 70, 57, and 49 d of grazing in yr 1, 2, and 3.

^{d,e,f}Differences between means with different superscripts in each year are significant ($P < .05$).

^g9-point system; 1 = emaciated, 9 = very obese.

mentation was to be controlled to maintain a mean body condition score of 5, seasonal body condition score increases were greater ($P < .05$) for cows fed alfalfa-grass hay in drylots or grazing corn crop residues with stockpiled berseem clover than for cows grazing corn crop residues without stockpiled berseem clover in yr 1. As designed, there were no differences ($P > .05$) in seasonal body condition score changes of cows from the three management systems in yr 2 and 3. However, similar to yr 1, body condition score increases of cows grazing corn crop residues with stockpiled berseem clover were greater ($P < .05$) than those of cows grazing corn crop residues without stockpiled berseem clover during the first half of the grazing season in yr 2.

Because of the difficulty in actually maintaining a mean condition score of 5 on a 9-point scale in small groups of primiparous and multiparous cows by supplementing alfalfa-grass hay as large round bales, hay feeding data are presented as least squares means using the deviation of the body condition score at the termination of grazing from the desired condition score of 5 as the covariate (Table 8). In each year, cows grazing corn crop residues with or without stockpiled berseem clover required less ($P < .05$) hay to maintain a body condition score of 5 than cows maintained in a drylot. However, there were no differences ($P > .05$) in the amounts of hay offered to cows grazing corn crop residues with or without stockpiled berseem clover to maintain a condition score of 5 when adjusted by covariance. The low amounts of hay needed by cows grazing corn crop residues without stockpiled berseem clover may have resulted, in part, from ear droppage caused by insect damage in these fields. Oat-berseem clover fields produced 2,038, 2,654, and 3,879 kg hay DM/ha in yr 1, 2, and 3 in the first two cuttings, a high propor-

tion of which was oat forage. Therefore, hay production from oat-berseem clover fields was deficient by -122 kg/cow in yr 1 and was in excess by 677 and 722 kg DM/cow of that needed to maintain a condition score of 5 in cows simultaneously grazing corn crop residues and stockpiled berseem clover at an area ratio of 2:1 and a grazing allowance of .99 cow/ha.

Discussion

Previous research has shown that protein supplementation with alfalfa hay or soybean meal resulted in similar DM intakes and digestibilities in cows fed

Table 8. Least squares means of the amounts of hay offered to cows maintained in a drylot or grazing corn crop residues with or without stockpiled berseem clover

Year	Winter system ^a		
	Drylot	Corn crop residues ^b	
		Without berseem clover	With berseem clover
		kg/cow	
1	1,950 ^{ce}	674 ^{de}	801 ^{de}
2	1,753 ^{ce}	355 ^{df}	207 ^{df}
3	1,285 ^{cf}	670 ^{de}	570 ^{de}

^aStandard error of the mean was 55.4, n = 2.

^bIn yr 1, 2, and 3, alfalfa-grass hay was first offered after 56, 10, and 20 d of grazing to cows grazing corn crop residues without stockpiled berseem clover and 60, 17, and 22 d of grazing to cows grazing corn crop residues with stockpiled berseem clover.

^{c,d}Differences between means in each row with different superscripts are significant ($P < .05$).

^{e,f}Differences between means in each column with different superscripts are significant ($P < .05$).

dormant tall grass-prairie forage when diets were balanced to be isonitrogenous (DelCurto et al., 1990b). Similarly, in our digestion experiment, the DM intake and digestibilities of DM, NDF, ADF, and CP in sheep increased as the proportion of alfalfa or berseem clover hay mixed with corn crop residues increased. Inasmuch as the incremental increases in DM intake and digestibility resulting from addition of alfalfa or berseem clover hay did not differ, it seems that the value of berseem clover hay as a supplement for corn crop residues was equivalent to that of alfalfa hay harvested at a comparable maturity. Furthermore, because the linear contrasts of hay supplementation level on DM intake and DM, NDF, ADF, and CP digestibilities were significant, the addition of either hay did not seem to cause associative feed effects that would be characterized by additive responses to supplementation (Ferrell, 1988).

Similar to a previous study (Hitz and Russell, 1998), grazing corn crop residues in this experiment reduced the amounts of hay required to maintain a condition score of 5 in gestating beef cows compared to maintenance in a drylot. In the study of Hitz and Russell (1998), gestating cows grazing stockpiled tall fescue-alfalfa or smooth bromegrass-red clover forage required less hay to maintain a condition score of 5 than cows grazing corn crop residues. In the present study, however, there were no differences in the amounts of hay required to maintain cows grazing corn crop residues with or without stockpiled berseem clover. This lack of difference in hay requirements of cows grazing corn crop residues with or without stockpiled berseem clover may have been related to the nutritional qualities of the forages and/or weather conditions.

Daily gains of calves grazing corn crop residues have been highly related to the amounts of grain remaining in the field (Fernandez-Rivera and Klopfenstein, 1989). Although the amount was not measured in yr 1 and 2 of the present study, it seemed that there were a large number of ears in the field, apparently caused by an infestation of the European corn borer. In yr 3, average masses of grain DM at the initiation of grazing in corn residues fields from the monoculture corn or corn-corn-oat/berseem clover cropping systems were 112 and 183 kg/ha of corn; this was less than the amounts observed by Gutierrez-Ornelas and Klopfenstein (1991). Because cows grazing crop residues from the corn monoculture cropping system had 50% more area of corn crop residues to graze than cows grazing corn crop residues with stockpiled berseem clover, corn grain allowances were 112 and 121 kg/cow for cows grazing corn crop residues with or without stockpiled berseem clover, respectively, in yr 3.

Although stockpiled berseem clover contained higher concentrations of IVOMD and CP and lower concentrations of NDF than corn crop residues at the initiation of grazing, the rate of decrease in IVOMD concentration tended to be higher and the rates of increase in NDF and ADF concentrations were greater in stockpiled berseem clover than in corn crop residues. The rapid rate of

deterioration in the nutritive value of stockpiled berseem clover was likely the cause of the smaller differences in the composition of stockpiled berseem clover and corn crop residues at the initiation of grazing in yr 3 when grazing was deferred by a delay in grain harvest. Similar changes in forage nutritive value caused by weathering during winter have been observed in large bales stored outdoors (Atwall et al., 1984; Brasche and Russell, 1988), corn crop residues (Lamm and Ward, 1981; Russell et al., 1993), stockpiled cool-season grass-legume (Hitz and Russell, 1998), and mixed-grass prairie (Johnson et al., 1998). In contrast to the greater rates of loss of nutritive value in stockpiled berseem clover than in corn crop residues observed in this experiment, no differences in the rates of change in nutritive value of stockpiled cool-season grass-legume forage or corn crop residues were observed in the study of Hitz and Russell (1998).

Because of differences in composition between corn crop residues and stockpiled berseem clover early in the grazing season, cows grazing corn crop residues with stockpiled berseem clover had greater increases in BW than cows grazing corn crop residues in the first half of the grazing season in yr 1 and 2 and lower BW losses than cows grazing corn crop residues in the first half of the grazing season in yr 3. The rapid decrease in the nutritive value of berseem clover, however, seemingly resulted in equal or lower increases in BW and body condition score between cows grazing corn crop residues with or without stockpiled berseem clover in the second half of the grazing seasons at nearly equivalent levels of hay supplementation each year. Despite the greater BW gains by cows grazing corn crop residues and stockpiled berseem clover than by those grazing corn crop residues alone in the first half of the grazing season, hay supplementation of cows grazing corn crop residues and stockpiled berseem clover was initiated only 4, 7, and 2 d after initiation of hay supplementation of cows grazing corn crop residues without stockpiled berseem clover in yr 1, 2, and 3. Therefore, the lack of efficacy of grazing stockpiled berseem clover for reducing the supplemental hay needs of cows grazing corn crop residues also may have been related to reduced access of the cattle to forage (Ward, 1978). Maximum snow covers during the experiments were 27.9, 40.6, and 25.4 cm in yr 1, 2, and 3, respectively (NOAA, 1995, 1996, 1997).

In conclusion, although berseem clover seems to be an adequate supplement for corn crop residues throughout the winter as a hay or for early winter as a stockpiled forage, the rapid rate at which it loses its nutritive value during winter limits the utility of stockpiled berseem clover for late winter grazing.

Implications

Grazing corn crop residues reduces the amount of hay needed to maintain body condition scores, relative to cows maintained in a drylot. Feeding increasing

amounts of berseem clover hay with corn crop residues linearly increased dry matter intake and digestibility at rates that were not different from equivalent levels of alfalfa hay. Grazing stockpiled berseem clover with corn crop residues increased cow body weight gains compared to grazing corn crop residues for the first half of the grazing season. Stockpiled berseem clover, however, was very susceptible to weather damage. Therefore, stockpiled berseem clover is most effective as a supplement for corn crop residues during late fall and early winter.

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