Feeding Value of Brachytic Forage Sorghum Compared with Corn Silage from First or Second Harvest for Lactating Dairy Cows

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ABSTRACT

The objective of this trial was to compare the production response of lactating Holstein cows to corn or forage sorghum silage produced from two crops. Corn was planted in April and harvested in July (CSS). A second corn crop was planted in July and harvested in November (CSF). A brachytic dwarf forage sorghum was planted in April, harvested in July (FSS), fertilized, and harvested a second time in November (FSF). All forage was ensiled in plastic bags and stored until the production trial began. Silages contained (DM basis) 8.0, 8.5, 9.0, and 9.5% CP; 39.0, 38.3, 54.2, and 55.1% NDF; 3.55, 2.83. 7.72, and 7.77% acid detergent lignin; and 48.1, 47.7, 31.5, and 29.1 NFC, for CSS, CSF, FSS, and FSF, respectively. Forty-eight mid-lactation Holstein cows (153.5 ± 37.2 DIM, 35.7 ± 6.2 kg/d milk, and 3.2 ± 0.6% fat) were assigned randomly to one of four diets differing in forage source. Cows were individually fed once daily behind Calan doors for 5 wk. Diets were balanced to provide equal concentrations of protein, fiber, and energy. No differences were observed in dry matter intake (DMI), milk yield, or milk composition among treatments: 22.4, 21.4, 22.0, and 20.6 kg/d DMI; 33.3, 34.0, 34.1, and 34.3 kg/d milk; 3.26, 3.07, 3.39, and 3.48% fat; and 2.75, 2.66, 2.61, and 2.66% protein for CSS, CSF, FSS, and FSF, respectively. Concentrations of milk urea nitrogen were lower (P = 0.001) for CSS compared with CSF, FSS, and FSF (11.2, 14.3, 16.0 and 15.8 mg/dL, respectively). No differences were observed in BW or BCS change during the trial. Results of this trial suggest that silage produced from brachytic forage sorghum, either as the first crop or regrowth, can support similar intake, milk yield and composition as diets based on corn silage.

INTRODUCTION

Forage sorghum has been grown as a forage in many areas of the Southeast where irrigation is not available or limited because of its lower water requirements compared with corn (Contreras-Govea et al., 2010). Texas researchers reported that forage sorghum produces similar DM yield as corn, but required 40% less water to produce the crop (Bean and McCollum, 2005). While forage sorghum can produce similar yield, it has lower starch concentrations resulting in lower energy concentrations compared with corn (Bean et al. 2005). When lactating dairy cows were fed diets based on normal forage sorghum, milk yield was not different from cows fed tropical corn silage (Nichols et al., 1998) but was lower than of cows fed temperate corn silage (Aydin et al. 1999). Varieties of forage sorghum with the brown midrib gene produce forage that has reduced lignin concentrations and higher NDF digestibility (McCollum et al. 2005; Contreras-Govea et al., 2010). When BMR forage sorghum was fed to lactating dairy cows, FCM yield was similar to that of cows fed corn silage based diets (Grant et al., 1995; Aydin et al., 1999; and Oliver et al, 2004). Some reports indicate that DM yield is lower for BMR compared with normal forage sorghum varieties (McCollum et al. 2005; Contreras-Govea et al., 2010). However, yield of BMR forage sorghum varieties was not different from normal forage sorghum varieties in the University of Georgia variety test trials (Day et al., 2010, 2011; Gassett et al., 2013).

Another issue with forage sorghum is that it is very susceptible to lodging. Varieties with the brachytic dwarf gene are shorter (approximately 1.8 m height versus 3.6+ m) than normal forage sorghum. The presence of the brachytic dwarf gene results in shorter internodes without affecting the number of leaves, leaf size, maturity, or yield. Most brachytic dwarf varieties also contain the BMR gene. These varieties are less susceptible to lodging as normal varieties and have become an attractive alternative for producers to use for forage production. To date, limited data are available on the feeding value of these hybrids compared with normal forage sorghum varieties.

In the semi-tropical regions of the Southeast, a second crop of forage can be harvested without replanting when forage sorghum is planted in early spring and allowed to ratoon. This could reduce production cost and reduce the negative aspect of the lower DM yield compared to corn. The average DM yield of forage sorghum varieties managed for two crops in the variety test plots at Tifton for 2010, 2011, and 2013 was 18.2 MT DM/ha for the first harvest and 11.8 MT DM/ha for the second harvest (Day et al., 2010, 2011; Gassett et al., 2013). No nutrient quality measures were reported and we are not aware of any trials that have been conducted to determine the production response of lactating dairy cows or growing animals fed forage sorghum silage harvested from a two harvest system. For producers with either limited capacity to irrigate or limited water resources, this system may provide an option to increase forage production while using less water for irrigation. Since a second crop would not have to be planted, it also provides an opportunity to reduce total labor and production cost in light of continued increases in fuel and energy cost.

The objective of this trial was to collect data on the nutrient quality of forage sorghum silage produced in a system where it is allowed to regrow after the first harvest and harvested a second time compared with two corn silage crops produced during the same period. The potential feeding value of the resulting silages was determined in a production trial.

MATERIALS AND METHODS

Forage Production

Temperate corn (Pioneer P1404, DuPont Pioneer, Johnston, IA Company, St. Louis, MO) was planted on March 22, 2012 at a seeding rate of approximately 79,070 seed/ ha. Fertilizer and herbicides were applied according to UGA recommendations. The crop was irrigated as needed to maintain soil moisture. Forage was harvested on July 24, 2012 and ensiled in a plastic bag until beginning of a production trial. The second crop (DeKalb 67-88, Monsanto Company, St. Louis, MO) was planted on July 31, 2012 and managed the same as outlined for the first crop. Corn was harvested on November 8, 2012 and ensiled in a plastic bag.

A brachytic dwarf brown midrib forage sorghum variety (Alta 7401, Alta Seeds, Amarillo, TX) was planted at a seeding rate of approximately 5.6 lb/ha on April 12, 2012. Fertilizer and herbicides were applied according to UGA recommendations. The crop was irrigated as needed to maintain soil moisture. Forage was harvested on July 25, 2012 when the grain has reached the dough stage of maturity and ensiled in a plastic bag until beginning of a production trial. The crop was fertilized and allowed to regrow and produce a second crop. The forage was harvested on November 9, 2012 at early dough stage of maturity and ensiled in a plastic bag.

Production Trial

Forty-eight lactating Holstein cows (16 primiparous and 32 multiparous) averaging 153.5 ± 37.2 DIM, 35.7 ± 6.2 kg/d milk, and 3.2 ± 0.6% fat were used in a 7 wk randomized design trial. Cows were trained to eat behind Calan doors (American Calan, Northwood, NH) before beginning the trial.

All cows were fed a basal diet based on corn silage for 2 wk and data collected for use as a covariate in the statistical analysis. At the end of the preliminary period, within parity cows were assigned to one of four treatments by ECM for the following 5 wk. Treatments include four forage sources: 1) summer corn silage (CSS), 2) fall corn silage (CSF), 3) summer forage sorghum (FSS), or 3) regrowth fall forage sorghum (FSF). Diets (Table 1) were formulated to provide equal concentrations of protein, NDF, and energy based on preliminary forage analysis and fed as a TMR once daily in amounts to provide a minimum of 5% orts.

The amount of feed offered and refused was recorded daily. Samples of dietary ingredients and experimental rations were collected for DM analysis three times each week. Rations were adjusted as necessary to account for changes in the DM content of individual ingredients. Individual samples were composited by week and ground to pass through a 1-mm screen using a Wiley mill (Thomas Scientific, Swedesboro, NJ). Forage samples were analyzed for concentrations of DM, ash (AOAC, 2000), CP (Leco FP-528 Nitrogen Analyzer, St. Joseph, MO), ADF (AOAC, 2000), NDF adjusted for ash (Van Soest et al., 1991), acid detergent lignin, 30 h NDF digestibility (Goering and Van Soest, 1970), sugar (Dubois et al., 1956), starch (Hall, 2009), ether extract, and minerals (AOAC, 2000). Samples of experimental diets were analyzed for DM, ash, CP, ADF, (AOAC, 2000) and NDF adjusted for ash (Van Soest et al., 1991). Concentrations of soluble protein, NFC, and NEl were calculated using forage chemical analysis and database values in Cornell Net Carbohydrate and Protein System 6.1 (Tedeschi et al., 2008).

Fermentation end product concentrations of the experimental silages were determined using the filtrate of a 25g wet sample blended with 200mL of distilled water. Sample pH was determined using 30 mL of the extract introduced to a Mettler DL12 Titrator (Mettler-Toledo, Inc., Columbus, OH) and titrated with 0.1 N NaOH to a pH of 6.5. Ammonia-N concentrations were determined by introducing a dilute sample (25 mL of extract and 75 mL of deionized water) to a Labconco Rapidstill II model 65200 analyzer (Labconco, Kansas City, MO) and titrating with 0.1 N HCl. Lactic acid concentrations were determined by measuring racemic lactate using YSI 2700 Select Biochemistry Analyzer (YSI, Inc., Yellow Springs, OH) on a sample of equal parts extract and deionized water and multiplying the value by 2 for total lactic acid. Concentrations of acetic, propionic, butyric, and iso-butyric acids were determined using a 3 mL sample of extract filtered through a 0.2 µm PVDF GD/X Whatman filter membrane (Whatman, Piscataway, NJ) and a 0.1 µL subsample was then injected into a Perkin Elmer AutoSystem gas chromatograph (Perkin Elmer, Shelton, CT) using a Restek column packed with Stabilwax-DA (Restek, Bellefonte, PA).

Cows were milked 3 times daily at 0700, 1500, and 2300h. Daily milk yields for each cow were recorded electronically (Alpro, DeLaval, Kansas City, MO). Milk samples were collected from three consecutive milkings once each week for analysis of milk fat, protein, lactose, SNF, and MUN concentrations by infrared spectrophotometric analysis with a Foss 4000 instrument (Foss North America, Eden Prairie, MN; Dairy One Cooperative, Ithaca, NY).

Individual BW was recorded on three consecutive days following the 0700 milking at the end of the pretrial period and at the end of the experimental period. To minimize variation, BW was recorded immediately after milking before allowing access to feed or water. Body condition scores were assigned by two individuals during the last week of the preliminary period and wk 5 of the experimental period as described by Wildman et al. (1982).

Data from the production trial were analyzed using the proc mixed procedure of SAS (SAS Institute, 2008). The model included the effects of covariate, parity, treatments, wk, and the interaction of treatment and wk. Cow within treatment was included as a random effect and wk was included as a repeated measure. Significance was declared when $P \leq 0.05$ and trends when $P > 0.05$

and ≤ 0.10. When significance was detected, the PDIFF option was used for mean separation.

RESULTS AND DISCUSSION

The chemical composition of the corn and forage sorghum silage from summer and fall harvest are presented in Table 2. The harvest of CSS was delayed by rain and mechanical breakdown resulting in higher DM and pH and lower total VFA concentrates than desired. In general, forage sorghum had higher concentrations of CP, NDF, ADF, lignin, and sugar than corn silage whereas corn silage had higher concentrations of starch, NFC, and NDF digestibility. There were minor differences in the chemical analysis of summer and fall silage within forage type except that starch content was slightly lower and starch digestibility was higher for forages harvested in the fall compared with those harvested in the summer.

The CP content of the experimental diets was similar (Table 3). Calculated concentrations of soluble protein were lower and RDP was higher for FSS compared with the other treatments. Concentrations of NDF and ADF were higher and NFC was lower for diets supplemented with FSS and FSF compared with those based on CSS and CSF. Calculated dietary NEl concentrations were higher for CSF compared with CSS, FSS, and FSF.

No differences were observed in DMI, yield of milk or components, or milk composition among treatments except that MUN concentrations were lower ($P < 0.001$) for CSS compared with CSF, FSS, and FSF. Interactions of treatment and wk were observed for DMI ($P < 0.0001$), milk fat percentage ($P = 0.004$), efficiency ($P < 0.0001$) and MUN concentrations ($P = 0.01$). The DMI for CSS was highest during wk 1 and lowest during wk 5 compared with the other treatments. Milk fat percentage was similar for all treatments during wk 1 and 2 but decreased for CSS and CSF after wk 2 and was lower than FSS and FSF during wk 4 and 5. Efficiency of ECM production (ECM/DMI) was lowest for CSS during wk 1, but remained steady throughout the trial whereas cows fed FSS and FSF were higher during wk 1 and 3 compared with CSS but no differences were observed among treatments during wk 2, 4 or 5. Concentrations of MUN were highest for FSS and lowest for CSS throughout the trial, whereas MUN for CSF and FSF increased during wk 2 and then decreased for CSF during wk 4 before increasing again during wk 5 for CSF. No differences were observed in change of BW or BCS during the 5 wk trial ($P > 0.10$)

Grant et al. (1995) reported higher DMI but no difference in milk yield when cows were fed diets based on BMR forage sorghum compared with those fed diets based on corn silage. Cows fed diets based on normal forage sorghum had lower DMI and milk yield than those fed either corn silage or BMR forage sorghum. Aydin et al. (1999) reported the results of two trials comparing BMR forage sorghum with corn silage, normal forage sorghum or alfalfa silage. In the first trial, cows fed the BMR or normal forage sorghum compared with that of cows fed corn silage or alfalfa. In both Grant et al. (1995) and Aydin et al. (1999), diets based on BMR or normal forage sorghum contained approximately 40% NDF (DM basis) compared with 34% NDF for the corn silage based diets. In a second trial, Aydin et al. (1999) reported higher milk yield for cows fed BMR forage sorghum compared with normal forage sorghum, but similar to corn silage. Efficiency (4% FCM/DMI) was highest for the diet based on BMR forage sorghum compared with corn silage and normal forage sorghum.

Results of the current trial suggest that silage produced from brachytic dwarf forage sorghum with the BMR trait can support similar milk yield and composition as cows fed diets based on corn silage. The results also suggest that forage harvested of brachytic dwarf forage sorghum from the regrowth will support similar milk yield and that produced from the first crop. This trial is being repeated to obtain additional data.

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Table 1. Ingredient composition of experimental diets (% of DM).

Ingredient	Corn silage	Forage sorghum
Corn silage[1]	38.71	
Forage sorghum[2]		38.71
Oat baleage	6.88	3.44
Brewers grains, wet	11.61	11.61
Whole cottonseed	5.59	
Ground corn	19.96	26.41
Soybean hulls	2.06	2.06
Soybean meal	3.48	6.06
Megalac[3]	1.72	1.72
Amino Plus[4]	2.84	2.84
Prolak[5]	3.18	3.18
Urea	0.26	0.26
Salt	0.26	0.26
Calcium carbonate	0.86	0.86
Potassium carbonate	0.60	0.60
Magnesium oxide	0.26	0.26
Sodium bicarbonate	0.77	0.77
Availa-4[6]	0.03	0.03
Potassium magnesium sulfate	0.17	0.17
Omigen-AF[7]	0.22	0.22
Monsenin, 3g/454 g[8]	0.38	0.38
Vitamin E, 20,000 IU/454g	0.02	0.02
Trace-mineral-vitamin premix[9]	0.14	0.14

[1] Corn silage was provided from silage harvested during the summer or fall

[2] Forage sorghum was provided from silage harvested during the summer or fall

[3] Calcium salts of long chain fatty acids, Arm Hammer Animal Nutrition, Church & Dwight Co., Inc. Princeton, NY

[4] Ruminally protected soybean meal, Ag Processing, Inc. Omaha, NE

[5] Marine and animal rumen undegradable protein supplement, H. J. Baker & Bros., Inc. Westport, CT

[6] Organic zinc, manganese, copper, and cobalt, Zinpro Corporation, Eden Prairie, MN.

[7] Immune stimulant, Prince Agri Products, Inc., Quincy, IL

[8] Rumensin, Elanco Animal Health, Indianapolis, IN.

[9] Mineral-vitamin premix contained (DM basis):): 26.1% Ca; 0.38% Mg; 1.76% S; 144 ppm Co; 9,523 ppm Cu; 1,465 ppm Fe; 842 ppm I; 28,617 ppm Mn; 220 ppm Se; 25,343 ppm Zn; 4,210,830 IU/kg Vitamin A; 1,684,330 IU/kg Vitamin D; 21,045 IU/kg Vitamin E.

Table 2. Chemical composition of experimental silages harvested.

	Corn silage		Forage sorghum	
	Summer	Fall	Summer	Fall
DM, %	46.6 ± 5.1	29.6 ± 2.0	28.7 ± 1.7	29.7 ± 3.4
	--------------------------------	% of DM	------------------------	
CP	8.0 ± 0.5	8.5 ± 0.3	9.0 ± 0.6	9.5 ± 0.6
NDIP	1.49 ± 0.20	1.10 ± 0.16	2.51 ± 0.21	2.24 ± 0.11
NDF	39.0 ± 1.1	38.3 ± 1.7	54.2 ± 1.7	55.1 ± 2.0
ADF	24.5 ± 1.2	24.0 ± 1.3	35.9 ± 1.2	36.0 ± 1.8
Lignin	3.6 ± 0.4	2.8 ± 0.2	7.7 ± 0.4	7.8 ± 0.1
NDFd, 30 h1	47.1 ± 2.8	53.0 ± 1.7	45.8 ± 3.3	37.4 ± 2.8
Ether extract	3.4 ± 0.1	3.6 ± 0.1	3.5 ± 0.4	3.0 ± 0.3
Sugar	1.4 ± 0.1	1.0 ± 0.2	2.2 ± 0.6	1.6 ± 0.3
Starch	37.2 ± 0.8	34.0 ± 1.7	16.8 ± 0.4	14.1 ± 2.2
Soluble fiber	7.1 ± 0.9	4.0 ± 0.8	5.6 ± 1.0	8.2 ± 0.8
Starch digestibility, 7 h	74.0 ± 4.6	82.6 ± 3.4	64.3 ± 3.8	76.8 ± 0.5
NFC	48.1 ± 1.1	47.7 ± 0.7	31.5 ± 1.1	29.1 ± 1.7
Ash	3.20 ± 0.35	4.19 ± 0.48	5.03 ± 0.28	4.73 ± 0.43
Total VFA	2.59 ± 0.50	10.62 ± 0.78	7.89 ± 0.80	6.85 ± 0.67
pH	5.11 ± 1.17	3.95 ± 0.40	4.12 ± 0.23	4.45 ± 0.19
	--------------------------------	% of total VFA	------------------------	
Lactic acid	1.3 ± 0.3	9.0 ± 0.9	2.1 ± 0.1	1.5 ±0.3
Acetic acid	1.04 ± 0.34	1.98 ± 0.50	4.89 ± 0.75	5.18 ± 0.34
Propionic acid	0.15 ± 0.03	0.08 ± 0.06	0.96 ± 0.45	0.17 ± 0.10
Butyric acid	ND2	ND	ND	ND
Isobutyric acid	0.01 ± 0.00	ND	ND	0.02 ± 0.00
1,2 Propanediol	0.69 ± 0.18	0.39 ± 0.19	0.27 ± 0.13	1.41 ± 0.22

1NDFd, 30h = 30 h NDF digestibility

2ND = not detected

Table 3. Chemical analysis of experimental diets based on corn or forage sorghum silage harvested in the summer or fall.

	Corn silage		Forage sorghum	
	Summer	Fall	Summer	Fall
DM, %	47.6	39.8	38.6	39.4
	-------------------------------- % of DM ------------------------			
CP	16.9	16.7	16.7	17.0
Soluble Protein1	4.6	4.9	3.9	4.7
RDP1	10.2	10.2	11.1	10.3
NDF	35.1	36.7	37.5	39.0
ADF	18.8	19.7	20.6	21.0
Ether extract	5.6	6.0	5.7	5.2
NFC1	38.0	37.7	35.6	35.4
	----------------------------- Mcal/kg of DM ---------------------			
NEl	1.61	1.72	1.61	1.63

1Calculated using Cornell Net Carbohydrate and Protein System 6.1 (Tylutku et al., 2008).

Table 4. Dry matter intake, milk yield and composition of cows fed diets based on corn or forage sorghum silage harvested in the summer or fall.

	Corn silage		Forage sorghum silage			
	Summer	Fall	Summer	Fall	SE	P
DMI, kg/d	22.4	21.4	22.0	20.6	1.0	0.58
Milk, kg/d	33.3	34.0	34.1	34.3	1.3	0.95
Fat, %	3.26	3.07	3.39	3.48	0.14	0.20
Fat, kg/d	1.08	1.04	1.16	1.19	0.07	0.52
Protein, %	2.75	2.66	2.61	2.66	0.04	0.13
Protein, kg/d	0.92	0.90	0.89	0.91	0.05	0.94
Lactose, %	4.65	4.72	4.69	4.72	0.03	0.36
Lactose, kg/d	1.55	1.60	1.60	1.62	0.06	0.87
SNF, %	8.30	8.29	8.19	8.27	0.06	0.54
SNF, kg/d	2.76	2.82	2.79	2.84	0.12	0.97
ECM, kg/d	31.9	31.5	32.9	33.6	1.4	0.78
Efficiency, ECM/DMI	1.43	1.48	1.50	1.63	0.08	0.24
MUN, mg/dl	11.2a	14.3b	16.0b	15.8b	0.83	0.001

abMeans in the same row with unlike superscripts differ ($P < 0.01$).