Comparison of Sorghum Silage vs Corn Silage

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INTRODUCTION

Corn silage is the primary forage used in dairy rations across the United States, but many dairy producers also utilize sorghum silage as a part of their feeding program. There is renewed interest in sorghum silage as a primary forage because it requires less water to produce and is more drought tolerant than corn, which has become more important in many regions of the world where drought is common and water availability for irrigation is limited or restricted. However, sorghum silage has been considered lower quality forage compared with corn silage and has been used primarily in diets that require less energy than needed by high producing dairy cows. There is considerable variation in yield, fiber content and digestibility, and lodging potential of sorghum varieties commercially available for silage production. Research on the use of sorghum silage, especially grain sorghum, in dairy rations is more limited than that for corn silage; but indicates that improved varieties and genotypes of sorghum silage can support milk yield and component composition comparable with that of corn silage. While forage sorghum may not be a complete replacement of corn silage in all settings, it can be successfully used in rations fed to lactating dairy cows and offers an option for forage production.

CHARACTERISTICS OF SORGHUM SILAGE

Sorghum is a tropical summer annual with high yield potential when provided good fertility and moisture. Compared with corn, sorghum has proportionally more stem and less leaf and head/ear resulting in forage that has higher fiber concentrations (Contreas-Govea et al., 2010). Sorghum requires 40 to 53 % less water to produce a crop than corn (McCorkle et al., 2007), which is important in regions where water is limited or restricted. Miron et al. (2007) reported improved water efficiencies of 51 and 18 % for normal forage and brown midrib (**BMR**) forage sorghum silage compared with corn silage, respectively. The increase in water efficiency varies with the yield of the crop produced. The lower improvement observed in water efficiency for BMR forage sorghum reported by Miron et al. (2007) was due to the lower dry matter (**DM**) yield of that variety compared with normal forage sorghum and corn.

Several new genotypes of sorghum have been developed and made available for forage production that have improved forage quality and/or yield including BMR, high water soluble carbohydrate (**WSC**) or *sweet* varieties, photoperiod sensitive (**PS**) varieties, and brachytic dwarf varieties. The BMR varieties have lower lignin concentrations and greater neutral detergent fiber (**NDF**) digestibility. There are several naturally occurring genes that convey the BMR trait in sorghum. The two most common genes used in forage sorghum are bmr-6 and bmr-18. The DM yields of these varieties have been reported to be 10 % lower than conventional forage sorghum, but there is considerable variation among varieties. Forage sorghum naturally has a higher lodging potential than corn, especially when planted at high populations

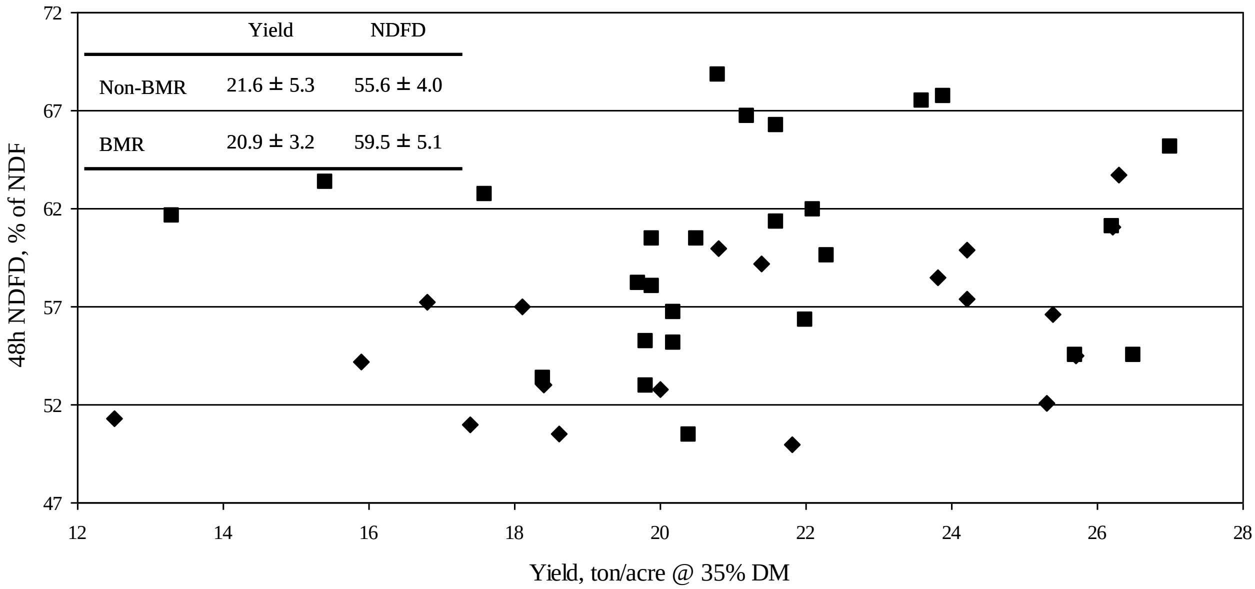

Figure 1. Relationship of yield and NDF digestibility of normal (♦) and BMR (■) forage sorghum varieties entered in the 2014 Texas Panhandle Sorghum Silage Trial (Bell et al., 2014).

and BMR varieties may have greater lodging potential because of the lower lignin concentrations. The WSC or sweet varieties contain more sugar which supports improved fermentation. The higher sugar content should provide more energy in support of milk synthesis or BW gain. Photoperiod sensitive varieties have delayed flowering which keeps the plant in a vegetative stage of maturity longer which should improve quality, but improvements in forage quality have not been consistently observed compared with normal forage sorghum. The PS varieties do have higher DM yield than normal sorghum varieties. Brachytic dwarf varieties have shorter internodes, greater leaf to stem ratio, and are considered to be more resistant to lodging. Many of the brachytic dwarf varieties also have the BMR gene and have become popular with dairy producers for forage production.

There is considerable variation in days to maturity, yield, plant height, lodging, and NDF digestibility among varieties. The extent of variation that exists is illustrated in Figure 1, which depicts the variation in DM yield and NDF digestibility, and Figure 2, which depicts the variation in DM yield and lodging of normal and BMR varieties entered in the 2014 Texas Panhandle Sorghum Silage Trial at Bushland (Bell et al., 2014). These figures illustrate the importance of reviewing variety test data to select varieties that have the combination of traits best suited for the forage quality and yield desired for specific feeding programs (i.e. high producing lactating cows versus dry cows or bred heifers).

Table 1. Chemical composition (mean ± standard deviation) of corn, normal forage sorghum, or BMR forage sorghum.

	Corn silage[1]	Forage Sorghum[1]		Forage Sorghum[2]		Grain sorghum[2]
Item	Normal	Normal	BMR	Normal	BMR	Normal
n =	8,640	1,498	132	26	34	8
DM, %	35.2 ± 4.9	32.8 ± 5.3	34.0 ± 6.5	32.3 ± 3.8	33.0 ± 3.0	32.6 ± 2.3
CP, %	8.1 ± 1.1	9.8 ± 2.4	10.6 ± 3.2	7.7 ± 1.0	7.9 ± 0.9	8.2 ± 0.3
ADF, %	25.3 ± 3.3	34.4 ± 4.59	34.3 ± 4.5			
NDF, %	40.9 ± 5.0	53.0 ± 6.8	54.2 ± 7.2	53.8 ± 9.2	49.4 ± 7.4	43.5 ± 2.4
NDFD, 30 h, %	56.5 ± 4.4	48.7 ± 7.0	54.0 ± 8.3			
NDFD, 48 h, %				54.6 ± 4.2	59.1 ± 5.0	58.8 ± 2.2
Lignin, %	3.2 ± 0.6	5.0 ± 0.9	4.6 ± 0.9	5.8 ± 1.1	4.8 ±0.8	4.7 ± 0.6
Sugar, %	1.3 ± 0.8	4.2 ± 2.3	5.3 ± 3.0			
Starch[3], %	32.1 ± 6.5	11.7 ± 8.0	10.3 ± 8.8	16.4 ± 9.6	20.0 ± 8.1	29.7 ± 3.2
Fat, %	3.2 ± 0.3	2.7 ± 0.4	2.9 ± 0.4	1.8 ± 0.5	2.1 ± 0.4	2.4 ± 0.2
Ash, %	4.1 ± 1.6	9.1 ± 3.5	8.9 ± 3.1			
Ca, %	0.25 ± 0.20	0.51 ± 0.35	0.44 ± 0.13			
P, %	0.23 ± 0.04	0.23 ± 0.06	0.26 ± 0.07			
Mg, %	0.16 ± 0.05	0.33 ± 0.11	0.32 ± 0.09			
K, %	1.14 ± 0.28	2.02 ± 0.76	2.23 ± 0.84			

[1]Analysis of silage samples submitted to Cumberland Valley Analytical Laboratory from January 1, 2013 through July 1, 2015.
[2]Analysis of unfermented samples from varieties entered in the 2014 Texas Panhandle Sorghum Silage Trial (Bell et al., 2014).
[3]Starch values reported for samples from Texas Panhandle Sorghum Silage Trial reflect concentrations at harvest.

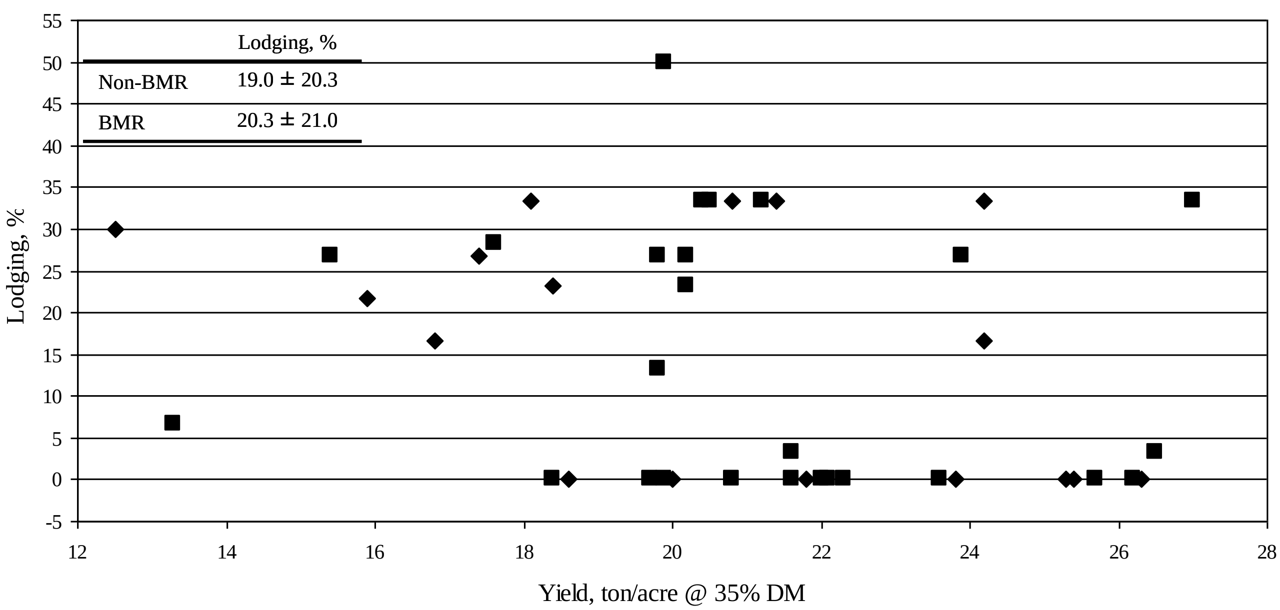

Figure 2. Relationship of yield and lodging of normal (♦) and BMR (■) forage sorghum varieties entered in the 2014 Texas Panhandle Sorghum Silage Trial (Bell et al., 2014).

The average chemical composition of corn, normal and BMR forage sorghum, and grain sorghum samples submitted to a commercial lab from the Plains and Southeast and analysis from the Texas Panhandle Sorghum Silage Trial (2014) are presented in Table 1. The standard deviations reported for each nutrient in Table 1 provide an indication of the variation observed in each nutrient for each of the forages. The differences reflect differences among varieties, stage of maturity, and changes during storage. In general sorghum silages have higher concentrations of protein, NDF, lignin, sugar, and ash; but lower starch and fat compared with corn silage. The BMR silages have similar composition as the normal varieties except for less lignin concentrations and higher NDF digestibility, which is typical for BMR varieties. The recommended stage of maturity for harvesting sorghum is early to late dough to optimize fiber and starch digestibility. Harvesting earlier than late vegetative or early head stage of maturity will result in silage with very low DM (< 25 % DM), which will result in excess seepage and a higher potential for undesirable fermentation characterized by higher concentrations of acetic and butyric acids and ethanol. Harvesting later results in lower starch digestibility.

PRODUCTION RESPONSE

Performance of lactating dairy cows fed sorghum silage differs depending on type of forage sorghum fed. Nichols et al. (1998) did not observe any difference in dry matter intake (**DMI**), yield of milk or component composition of cows fed diets based on either tropical corn silage or normal forage sorghum. However, tropical corn has higher lignin and lower starch concentrations than normal corn silage. Grant et al. (1995) compared the performance of lactating cows fed diets containing 65 % forage provided by normal or BMR forage sorghum, second cutting alfalfa silage, or corn silage. The DMI was lowest for diets based on alfalfa silage and highest for BMR forage sorghum compared with normal forage sorghum and corn silage. Milk yield and percentage fat and protein were lower for cows fed the normal forage sorghum diet compared with the other forages. No differences were observed in milk yield or component composition of cows fed BMR forage sorghum compared with corn silage or alfalfa silage. Aydin et al. (1999) reported the results of 2 additional trials from the same laboratory. In the first trial dietary NDF content of diets with normal and BMR forage sorghum was higher than those based on corn or alfalfa silage (39.7, 40.3, 29.1, and 34.3 % of DM, respectively). The differences in dietary NDF content did not affect DMI, which averaged 23.4 kg/d. Yield of milk, fat, and protein was highest with corn silage, intermediate for BMR forage sorghum and alfalfa silage, and lowest for normal forage sorghum. In the second trial, diets were based on a blend of alfalfa silage (17.5 % of DM) and either normal forage sorghum, BMR forage sorghum, or corn silage (35.3 % of DM) and contained similar concentrations of NDF (32.3, 31.6, and 31.9 % of DM, respectively). In this trial milk yield was higher for BMR forage sorghum compared with normal forage sorghum, but was not different from corn silage. No differences were observed in yield or percentage of milk components.

Oliver et al. (2004) compared normal forage sorghum, BMR genotypes -6 and -18 with corn silage. Each of the diets contained 40 % of the dietary DM from one of the 3 forages plus an additional 10 % from alfalfa hay. Diets were balanced to provide similar

CP, NDF, and starch concentrations. No differences were observed in DMI among treatments, but milk yield and milk fat percentage and yield were lower for diets based on normal forage sorghum compared with BMR-6 and corn silage, but not different with BMR-18. Efficiency (4 % FCM/DMI) was lower with normal forage sorghum compared with the other treatments. Miron et al. (2007) reported the results of a trial comparing normal forage sorghum, BMR forage sorghum, and corn silage. No differences were observed in DMI, but milk yield was higher for corn silage and lowest for normal forage sorghum but not different from BMR forage sorghum. Milk fat percentage was lower with corn silage compared to both normal and BMR forage sorghum. Milk protein percentage was highest for corn silage, intermediate for BMR forage sorghum, and lowest for normal forage sorghum. Concentrations of MUN were higher for corn silage compared with normal and BMR forage sorghum.

Limited research has been conducted examining the effects of using forage sorghum in combination with other forages in diets fed to lactating dairy cows. Boyd et al. (2008) reported the results of a trial in which diets based on a blend of normal forage sorghum and ryegrass silage (50:50 or 75:25) and supplemented with either ground corn, hominy feed, or a 50:50 blend of corn and hominy were fed to mid-lactation Holstein cows. Diets contained similar CP, NDF, and energy concentrations although starch concentrations were slightly lower for the 50:50 compared with the 75:25 blend (20.7 and 24.6 % of DM, respectively). No differences were observed in DMI, milk yield, or concentrations of components; but yield of milk fat tended to be higher and ECM yield and efficiency were higher for the 75:25 compared with the 50:50 blend. The authors suggested that the slightly higher starch content of the 75:25 provided by the sorghum silage potentially supported improved ruminal fermentation resulting in the improvements in yield of milk fat and ECM.

Table 2. Chemical composition of two corn (CS) and forage sorghum silage (FS) crops harvested in the summer (S) or fall (F)[1].

	Year	CSS	CSF	FSS	FSF
DM, %	1	46.6 ± 5.1	29.6 ± 2.0	28.7 ± 1.7	29.7 ± 3.4
	2	33.2 ± 2.3	36.4 ± 2.6	24.6 ± 0.5	27.3 ± 1.5
CP, %	1	8.0 ± 0.5	8.5 ± 0.3	9.0 ± 0.6	9.5 ± 0.6
	2	8.1 ± 0.4	8.2 ± 0.5	9.5 ± 0.5	11.3 ± 0.3
NDF, %	1	39.0 ± 1.1	38.3 ± 1.7	54.2 ± 1.7	55.1 ± 2.0
	2	39.0 ± 2.0	39.0 ± 1.7	56.1 ± 2.0	51.5 ± 0.8
NDFD,%	1	47.1 ± 2.8	53.0 ± 1.7	45.8 ± 3.3	37.4 ± 2.8
	2	52.8 ± 1.9	52.1 ± 3.5	51.0 ± 1.2	52.7 ± 0.8
ADF, %	1	24.5 ± 1.2	24.0 ± 1.3	35.9 ± 1.2	36.0 ± 1.8
	2	25.2 ± 1.6	22.8 ± 1.1	37.0 ± 0.8	34.0 ± 0.9
Ash, %	1	3.20 ± 0.35	4.19 ± 0.48	5.03 ± 0.28	4.73 ± 0.43
	2	3.20 ± 0.35	3.11 ± 0.18	5.02 ± 0.19	5.79 ± 0.40

[1]Trials were conducted in 2012 (Year 1) and repeated in 2014 (Year 2).

Table 3. Performance of lactating cows fed diet based on corn (CS) or forage sorghum silage (FS) harvested in the summer (S) of fall (F)[1].

	Year	CSS	CSF	FSS	FSF	SE	*P*
DMI, kg/d	1	21.4	23.1	22.6	21.1	1.2	0.57
	2	25.0	22.5	23.4	23.2	1.0	0.30
Milk, kg/d	1	32.2	33.4	32.9	33.5	1.5	0.92
	2	35.6	34.5	33.8	35.7	1.1	0.56
Fat, %	1	3.20[a]	2.91[a]	3.42[b]	3.53[b]	0.14	0.02
	2	3.61[d]	3.26[c]	3.70[d]	3.67[d]	0.12	0.06
Protein, %	1	2.80	2.70	2.64	2.69	0.05	0.15
	2	2.55	2.62	2.57	2.63	0.03	0.13
Lactose, %	1	4.63[a]	4.88[b]	4.87[b]	4.82[b]	0.40	0.01
	2	4.68	4.67	4.74	4.72	0.02	0.14
SNF, %	1	8.28	8.33	8.21	8.26	0.07	0.65
	2	8.07	8.09	8.13	8.15	0.04	0.68
ECM, kg/d	1	30.8	30.4	31.9	33.1	1.4	0.64
	2	34.6	35.4	32.7	36.3	1.0	0.15
Efficiency	1	1.44	1.32	1.41	1.57	0.09	0.55
	2	1.37	1.48	1.46	1.48	0.04	0.26
MUN, mg/dl	1	10.6[a]	13.4[b]	14.9[b]	15.3[b]	0.8	0.002
	2	8.2a	8.8a	11.5b	11.4b	0.31	<0.0001

[a,b]Means with unlike superscripts in the same row differ ($P < 0.01$)
[c,d]Means with unlike superscripts in the same row differ ($P < 0.10$).
[1]Trials were conducted in 2012 (Year 1) and repeated in 2014 (Year 2).

In recent years, brachytic dwarf varieties with the BMR-6 gene have been adopted by producers because of their lower lodging potential and ability to produce similar DM yield as normal forage sorghum varieties. In semi-tropical areas, forage sorghum will produce a second crop without replanting, which would reduce production cost. For the last few years, the University of Georgia has included a measurement of regrowth as part of the variety test data. For 2010 the variety test plots were planted on April 16 and the first crop was harvested on July 28 with a second harvest on October 18. The average DM yield for varieties was 7.9 ton/acre for the first harvest and 6.4 ton/acre for the second harvest. We have completed 2 trials comparing the performance of lactating dairy cows fed silage harvested from spring and summer corn crop with forage sorghum silage harvested from a brachytic dwarf variety planted in the spring and allowed to ratoon after the first harvest. The chemical composition of the silages harvested in 2012 (Trial 1) and 2014 (Trial 2) are presented in Table 2. The composition of the first and second corn silages was similar except that the fall crop had lower concentrations of starch. The 2 forage sorghum silage crops were similar in composition and had higher concentrations of fiber and lower starch than corn silage. No differences were observed in DMI, milk yield, or component composition among the forages except that milk fat percentage was higher for both diets based on forage sorghum compared with corn silage (Table 3). Concentrations of MUN were lower for the first corn silage harvested in the summer compared with the other treatments. We repeated this trial in 2015 and the results are presented in Table 3. In agreement with the first trial, there were no differences in DMI or milk yield.

Table 4. Performance of lactating dairy cows fed diets based on corn (CS), whole plant grain sorghum (WPGS), or normal forage sorghum silage (FS)[1].

	CS	WPGS	FS	SE	*P*
DMI, kg/d	20.0	20.0	18.2	0.5	0.07
Milk, kg/d	25.4[a]	24.6[a,b]	23.6[b]	0.4	0.05
Fat, %	4.08	4.33	4.16	0.08	0.14
Fat, kg/d	1.03	1.06	0.98	0.02	0.09
Protein, %	3.36	3.28	3.31	0.07	0.31
Protein, kg/d	0.85[a]	0.81[a,b]	0.77[b]	0.02	0.05
4% FCM, kg/d	25.6	25.7	24.1	0.5	0.07
Efficiency	1.28	1.29	1.32	0.03	0.63
MUN, mg/dl	10.7[a]	11.9[a,b]	12.9[b]	0.02	0.05

[1]Colombini et al., 2012.

[a,b]Means in the same row with unlike superscripts differ ($P < 0.05$).

In contrast, milk fat percentage was lower for the second corn silage compared with the other forages and MUN concentrations were higher for both forage sorghum silages compared with the corn silages. No differences were observed in concentrations of milk protein, lactose, or SNF or efficiency of milk production.

Data on the feeding value of sweet sorghum are limited. Amer et al. (2012) reported lower milk yield and higher milk fat percentage for cows fed diets based on sweet forage sorghum plus corn silage compared with a control diet based on alfalfa and corn silage. Yield of enery-corrected milk (**ECM**) and efficiency of milk production was not different among diets suggesting that these varieties have potential for use in diets fed to high producing dairy cows. Additional data are needed to determine their full potential.

Limited research data are available on feeding grain sorghum silage to lactating dairy cows during the last 2 decades. In general grain sorghum has been considered to be higher quality when harvested before late dough stage of maturity than normal forage sorghum, partially because of the additional starch provided by the grain (Bolsen, 2004). No differences were observed in DMI, milk yield, or component composition of mid-lactation cows fed diets based on inoculated or un-inoculated corn silage compared with grain sorghum silage (Bolsen et al., 1989). Recently Colombini et al. (2012) reported the results of a trial comparing diets based on corn, whole plant grain sorghum, or normal forage sorghum silages (Table 4). The corn silage, whole plant grain sorghum, and normal forage sorghum provided 41.5, 36.7, and 28 % of the dietary DM, respectively, to maintain equal NDF concentrations. Starch was equalized using corn meal. No differences were observed in DMI or percentage milk fat and protein, but yield of milk and milk protein were lowest and MUN highest for normal forage sorghum compared with corn. Whole plant grain sorghum supported similar DMI, milk yield, and component composition as corn silage.

CONCLUSIONS

There is considerable variation in yield, lodging potential, and NDF digestibility of varieties currently available, so it is important that producers and their advisors study the available information to select varieties that can produce the yield and quality needed to support milk production. The available data indicate that BMR forage sorghum or grain sorghum can support DMI, milk yield, and component composition comparable to that of corn silage; but diets based on regular forage sorghum will result in lower milk yield. Based on higher MUN concentrations observed when diets are based on sorghum, there is potential to improve dietary nitrogen utilization compared with corn silage.

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