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Summary

Forage sorghum (*Sorghum bicolor* L.) and sorghum × sudan (*Sorghum bicolor* sssp. Drummondii) are important annual forages in the High Plains. Advancements in brown mid-rib (BMR) cultivars will likely affect forage yield and nutritive values. A study was initiated in 2017 at the Southwest Research-Extension Center near Garden City, KS, comparing one variety each of BMR and non-BMR forage sorghum and sorghum × sudan cultivars. Forage type and growth stage affected yield and nutritive value, and occasionally there was an interaction between forage type and maturity.

Introduction

Forage variety testing has shown yield and nutritive value differences across forage sorghum and sorghum × sudan varieties (Holman et al. 2016, 2017, 2018). Growers commonly report differences in palatability of free-choice sorghum hay fed to cattle (Holman, unpublished data). The differences in palatability may be in part related to maturity of the forage and forage type. Therefore, one cultivar of each sorghum type was harvested at different maturities for yield and nutritive value to gain better insight into feed value differences.

Study Objectives

1. Compare yield and nutritive value differences of forage sorghum and sorghum × sudan BMR and non-BMR types.
2. Evaluate maturity differences (boot, heading, flowering, and soft dough) on forage yield and nutritive value.

Experimental Procedures

Annual forages were grown in 2017 at the Southwest Research-Extension Center near Garden City, KS. The study design was a randomized complete block design with four replications. Treatment was forage sorghum type (forage sorghum and sorghum × sudan) with and without the BMR trait, harvested at boot, heading, flowering, and soft dough for a total of 16 treatments. Plots were 15-ft wide × 60-ft long. Forage sorghum cultivars were non-BMR 'Canex' forage sorghum (FS), BMR 'Canex 210' forage sorghum (FSBMR), non-BMR 'Super Sugar' sorghum × sudan (SS), and BMR Sweet Six sorghum × sudan (SSBMR). Sorghum cultivars were planted on June 1, 2017, and harvested at boot, heading, flowering, and soft dough growth stages.

Forage nutrient components measured were dry matter yield, ash, lignin, acid detergent fiber (ADF), neutral detergent fiber (NDF), digestible neutral detergent fiber (NDFD), total digestible nutrients (TDN), crude protein (CP), relative feed quality (RFQ), milk₂₀₀₀/ton, and milk₂₀₀₀/a.

Results and Discussion

There was a significant interaction between forage type and growth stage for ADF and NDF (Table 1). Acid detergent fiber ranged from 34.4% (FS at boot) to 39.9% (SSBMR at heading), and NDF ranged from 50.4% (FS at dough) to 58.7% (SSBMR at flowering). Highly digestible forage grass would have an ADF < 35% and NDF < 50%. All of the fiber contents measured in this study would be considered lower-quality and less digestible regardless of forage type or maturity. The significant interaction was caused by SSBMR having greater ADF and NDF concentration at heading and dough than other forage types, and SSBMR having lesser ADF and NDF at boot. This suggests fiber content of SSBMR rapidly increased post-heading, resulting in forage with lower digestibility post-heading. It may be more critical to harvest SSBMR early than other forage types for best forage quality. Growth stage affected yield, ash, lignin, TDN, CP, milk/ton, and milk/a (Table 2). All forage attributes were affected by forage type (Table 3).

Growth Stage

Dry matter yield was greatest at dough and not different among other growth stages (Table 2). Harvesting at dough stage increases both forage and grain, thus increasing overall yield. These results also suggest a minimal yield penalty by harvesting early, yet harvesting early might increase overall forage quality and palatability. Ash content was highest at boot and lowest at dough. It is unclear why ash tended to be higher with earlier maturity, but might be due to less nutrient uptake as the plants mature. Lignin content was highest at dough and similar across the other growth stages. ADF was higher at boot than dough, while NDF was similar across growth stages. The grain (starch) component of the plant is more digestible and thus likely resulted in lower ADF at dough.

Neutral detergent fiber digestible (NDFD) and *in vitro* true dry matter digestibility (ITVD) were similar across growth stages. Crude protein decreased with maturity and was highest at boot. RFQ was similar across growth stages. TDN and milk/ton were highest at dough and lowest at boot, correlating with ADF content. The increased digestibility and improved energy at dough was likely due to the grain component of the forage. Milk/ton and milk/a were highest at dough and similar across the other growth stages.

Forage Type

Of the varieties evaluated, dry matter yield of forage sorghum (FSBMR and FS) tended to be greater than sorghum × sudan (SSBMR and SS) in a one-cut hay system (Table 3). Yield can vary greatly among varieties and environment (Holman et al. 2017a, 2017b, and 2018). Sorghum × sudan as a group tends to have greater regrowth than forage sorghum, and regrowth was not measured in this study. Ash content was highest in SSBMR and no different than the other forage types. It is unclear why ash content was higher in SSBMR.

Lignin content was highest in SS and FS, and lower in SSBMR and FSBMR, which coincides with the BMR trait having less lignin. Fiber content (ADF and NDF) tended to be higher in sorghum \times sudan (SSBMR and SS), than forage sorghum (FSBMR and FS), but the differences between forage types was negligible. Fiber digestibility (NDFD and IVTD) tended to be greater among forage sorghum (FSBMR and FS) than sorghum \times sudan (SSBMR and SS), although no difference was observed between FS and SSBMR. This indicates better fiber digestibility of SSBMR compared to SS. Crude protein content was greatest in SSBMR, and FSBMR was greater than FS, indicating BMR improved crude protein content.

Relative feed quality (RFQ) combines fiber digestibility and crude protein to provide a nutrient value index to compare similar forages, total digestible nutrients (TDN) is a measurement of digestibility energy, and milk per ton is a measurement of starch and fiber digestibility. FSBMR and FS had greater RFQ, TDN, and milk per ton than SSBMR or SS, largely caused by the differences in fiber content and fiber digestibility between the two forage types. Milk per acre combines the value of forage quality (milk per ton) and yield (dry matter yield/a) into one term. Milk per acre was greatest with FSBMR and lowest with FS and SSBMR, largely driven by yield/a since forage quality differences were minor among forage types.

Conclusion

Harvesting forage sorghum or sorghum \times sudan at early maturity (boot) increased crude protein content, did not reduce yield compared to harvesting at heading or flowering, and would likely improve palatability when fed as free choice hay. However, if feeding as part of a total mixed ration where bunk sorting would be limited, harvesting forage sorghum later at soft dough increased fiber digestibility and yield. SSBMR in this study increased fiber concentration more with plant maturity than the other forage types.

In a one-cut system, forage sorghum will generally provide greater yield than sorghum \times sudan, but sorghum \times sudan typically has greater regrowth than forage sorghum. BMR forage types had less lignin and greater CP. Fiber content (ADF and NDF) was lower and forage digestibility (NDFD and IVTD) was greater among forage sorghum plots than sorghum \times sudan. If regrowth is not required, then BMR forage sorghum can provide the most digestible forage.

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Table 1. Analysis of variance summary of treatment effects on forage yield and nutritive value

	Yield	Ash	Lignin	ADF	NDF	NDFD	TDN	IVTD	CP	RFQ	Milk/ton	Milk/a
	Dry matter lb/a	----- % -----										
Rep	0.006	0.98	0.12	0.04	0.29	0.25	0.60	0.30	<0.0001	0.24	0.63	0.03
Growth stage	<0.0001	<0.0001	0.02	0.16	0.24	0.52	0.01	0.88	<0.0001	0.50	0.01	<0.0001
Type	0.0014	<0.0001	<0.0001	0.01	0.01	<0.0001	<0.0001	<0.0001	<0.0001	0.00	<0.0001	0.00
Growth stage * type	0.734	0.34	0.49	0.05	0.04	0.39	0.34	0.11	0.23	0.42	0.31	0.70

ADF = acid detergent. NDF = neutral detergent fiber. NDFD = digestible neutral detergent fiber. TDN = total digestible nutrients. ITVD = *in vitro* true dry matter digestibility. CP = crude protein.
RFQ = relative feed quality.

*ANOVA test of the significant interaction between growth stage and type.

Table 2. Growth stage effects on forage yield and nutritive value

	Yield	Ash	Lignin	ADF	NDF	NDFD	TDN	IVTD	CP	RFQ	Milk/ton	Milk/a
	Dry matter lb/a	----- % -----										
Boot	5596.4	13.23	6.26	37.88	56.31	59.00	54.53	77.82	9.35	102.66	2396.50	6753.20
Heading	6122.0	11.83	6.06	37.54	56.24	59.59	56.14	77.91	8.88	107.91	2530.94	7813.30
Flowering	6627.1	10.98	6.08	37.19	55.97	57.92	56.51	77.22	8.33	107.34	2572.69	8545.90
Dough	9161.5	9.99	6.64	36.39	54.61	58.09	58.09	77.68	7.04	107.91	2709.13	12491.10
LSD ¹	1141.7	0.97	0.38	1.34	1.87	2.37	1.94	1.76	0.75	7.68	160.35	1830.00

¹LSD = least significant difference at $P \leq 0.05$.

ADF = acid detergent. NDF = neutral detergent fiber. NDFD = digestible neutral detergent fiber. TDN = total digestible nutrients. ITVD = *in vitro* true dry matter digestibility. CP = crude protein.
RFQ = relative feed quality.

Table 3. Forage type effects on forage yield and nutritive value

	Yield	Ash	Lignin	ADF	NDF	NDFD	TDN	IVTD	CP	RFQ	Milk/ton	Milk/a
	Dry matter lb/a	----- % -----										
Forage sorghum	6349.6	10.60	6.58	36.39	53.83	59.38	57.91	78.88	7.58	109.00	2689.88	8649.80
Forage sorghum BMR	7918	10.82	5.55	36.52	55.84	62.72	58.46	79.93	8.49	115.67	2709.88	10902.90
Sorghum sudan	7418.7	11.11	6.83	37.70	56.40	53.01	54.59	74.26	7.98	99.41	2436.07	9030.30
Sorghum sudan BMR	5789.5	13.53	6.17	38.46	57.09	58.89	54.07	77.19	9.51	100.74	2356.31	6903.40
LSD ¹	1142.8	0.97	0.38	1.34	1.87	2.37	1.94	1.76	0.75	7.69	160.51	1831.80

¹LSD = least significant difference at $P \leq 0.05$.

ADF = acid detergent. NDF = neutral detergent fiber. NDFD = digestible neutral detergent fiber. TDN = total digestible nutrients. ITVD = *in vitro* true dry matter digestibility. CP = crude protein.
RFQ = relative feed quality.