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Forage Quality and Agronomic Traits of Experimental Forage Sorghum Hybrids

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Summary

Our objective was to determine the variability in forage quality traits among 12 F1 forage sorghum (*Sorghum bicolor* L. Moench) hybrids managed for silage and to determine the relationships among yield, morphological, and chemical composition. The hybrids included some developed specifically for biomass energy production. The hybrids were grown for 3 years at Stephenville on a Windthorst fine sandy loam (fine, mixed, thermic, Udic Paleustalfs) soil. Dry matter (DM) yield, shoot density, and plant part proportions were measured at harvest. Whole plant samples were analyzed for crude protein (CP), acid detergent fiber (ADF), acid detergent lignin (ADL), and in vitro true digestibility (IVTD). Significant differences were found among hybrids for all traits. The hybrid ATx623*EBA3 had the lowest IVTD and highest fiber concentrations.

Correlations of chemical components with morphological components changed from year to year, except for ADF, which was correlated positively with leaf proportion each year ($r = 0.34$, $P = 0.0003$). Yield was negatively correlated with IVTD 2 out of 3 years ($r = -0.53$ to -0.63) and positively correlated with plant height each year ($r = 0.37$ to 0.87). There was no year-by-hybrid interaction for total DM yield or shoot density. Results indicate that forage quality can be improved in sorghums; however, a compromise between yield and nutritive value may be necessary.

Introduction

Sorghum frequently is grown as a forage crop in Texas because of its inherent qualities of high biomass yields, drought tolerance, and adaptability to late planting after winter crops (Miller 1976). Even though considerable effort is directed toward developing sorghum hybrids for forage, few are evaluated for forage quality traits. For example, in a survey of 26 private and public plant breeders working with forage sorghums, Kalton (1988) found that the traits receiving the most attention were total yield, standability, and disease and insect resistance. Only one respondent was specifically evaluating forage sorghums for improved nutritive value (i.e., digestibility).

Previous work in Texas had identified several high-yielding sorghums as candidates for biomass energy production. These hybrids were tall, late maturing, tropically adapted types. However, these sorghums have not been evaluated under forage management for forage quality. It was assumed that those hybrids good for biomass energy production should be useful as forage for animals also.

Our objective was to evaluate several experimental F_1 hybrids of forage sorghum, including those developed for biomass energy production, for agronomic as well as forage quality traits.

Materials and Methods

Twelve F_1 hybrids (five two-way and seven three-way crosses) of forage sorghum were grown in 1989, 1990, and 1991 at the Texas A&M University Agricultural Research and Extension Center, 2 mi north of Stephenville. Plots consisted of two 30-ft rows spaced 3 ft apart. Soil analysis indicated an average pH of 7.1, NO_3-N at 3 ppm, phosphorus (P) at 2 ppm, and potassium (K) at 176 ppm of air-dry soil for the 3 years. The plot area was chisel-plowed, disked twice, then bedded into rows 3 ft wide each year. Fertilizer was applied at the rate of 160-80-80 lb of nitrogen (N), P_2O_5, and K_2O, respectively, in 1989; 160-85-60 in 1990; and 180 lb of N, 70 lb of P_2O_5, and 10 lb $ZnSO_4$ in 1991. Fertilizer was incorporated with the last disking operation. Weeds were controlled by me-

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Table 2. Forage quality traits of 12 F_1 sorghum hybrids during 3 years at Stephenville, Texas. Data are from initial growth harvests in each year. Crude protein data are 3-year averages.

	IVTD†			ADF			ADL			CP
Hybrid	1989	1990	1991	1989	1990	1991	1989	1990	1991	3-yr avg
	% of dry matter									
ATx623*TMTx430	76.3	77.3	74.2	31.0	28.8	28.4	3.87	2.98	3.43	7.25
ATx623*Rio	74.7	76.6	73.4	30.0	28.6	31.3	3.78	3.28	3.93	6.19
ATx623*EBA3	67.5	69.3	73.0	38.6	37.0	33.6	5.60	4.83	4.28	6.00
ATx623*Grassl	72.1	72.6	73.0	33.0	30.8	31.4	4.68	3.94	3.77	5.94
ATx623*Hegari	74.5	73.4	74.5	33.2	30.6	30.5	4.38	4.06	3.47	6.00
AAtlas*Hegari	74.2	72.2	74.0	33.0	30.8	29.7	4.02	4.35	3.67	5.75
A2Tx632*Hegari	75.2	73.6	74.2	31.7	31.2	31.0	4.17	4.03	3.78	6.63
(A2Tx2752*BAZ9504)*Hegari	72.9	70.8	72.6	35.0	30.3	31.7	4.43	4.33	4.06	5.56
(A28602*BAZ9504)*Hegari	76.4	73.9	75.0	28.0	29.2	29.4	4.01	3.93	3.56	5.56
(A28602*BTx623)*Hegari	76.6	74.2	74.6	28.8	28.3	30.5	3.80	3.58	3.51	5.88
(ATx378*B8106)*Hegari	73.3	73.0	74.2	34.6	29.5	29.3	4.52	3.81	3.70	5.88
(ATx378*Atlas)*TMTx430	75.5	76.5	72.8	31.1	29.8	29.5	3.83	2.95	3.78	6.56
Mean	74.1	73.6	73.8	32.3	30.4	30.6	4.26	3.84	3.74	6.13
CV (%)	1.9	3.0	1.4	5.9	6.1	3.7	6.70	10.1	7.3	12.9
LSD (0.05)	2.34	3.71	NS	3.23	3.16	1.90	0.48	0.66	0.46	0.74

† IVTD = in vitro true digestibility; ADF = acid detergent fiber; ADL = acid detergent lignin; CP = crude protein.

by year. Differences in IVTD among hybrids were significant in 1989 and 1990 but not in 1991. The range in IVTD was 10 percentage units in 1989 and 8 units in 1990. Ranges for ADF were 11 units in 1989, 10 units in 1990, and 5 units in 1991. Ranges for ADL were 1.8 units in 1989, 1.9 units in 1990, and 0.8 units in 1991.

In 1989 and 1990, ATx623*EBA3 had the lowest IVTD and the highest ADF and ADL concentrations. The hybrids with TMTx430 as the male parent were among the most digestible hybrids in 1989 and 1990 and had a high CP concentration during the 3 years. The TMTx430 hybrids and A2Tx632*Hegari had higher CP concentrations than the others did. ATx623*TMTx430 had the highest CP concentration.

These data indicate that differences in yield, morphological composition, and forage quality are significant among experimental hybrids of sorghum for forage. However, the hybrids with higher forage quality, ATx623*TMTx430 and (ATx378*Atlas)*TMTx430, also were lower yielding. The highest yielding hybrid (ATx623*Hegari) ranked intermediate in forage quality among the other hybrids.

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chanical cultivation each year. Granular chlorpyrifos [O,O-diethyl O-(3,5,6 trichloro-2-pyridyl) phosphorothioate] was applied at 2 oz per ft of row in 1-in. bands each year to control soilborne insects. The hybrids were planted at 8 lb of seed acre^{-1} with a two-row planter on 22 Apr. 1989, 23 Apr. 1990, and 30 Apr. 1991. The experimental design was a randomized complete block with three replicates. The experimental plot was not irrigated.

Plots were harvested when each hybrid reached the milk to soft-dough stage, and a regrowth harvest was taken in October or November. The center 10 ft from each row was harvested, and fresh weight was recorded. Plants were cut by hand with a machete to leave a 4- to 6-in. stubble. At each harvest, four to six random plants were ground in a leaf mulcher, and a 1-lb subsample was taken and dried at 130 °F for 48 hr to determine DM proportion. The samples from the initial harvests each year were saved for chemical analysis. In 1990 and 1991, total culms (primary plant plus tillers) were counted in a 5-ft section of each row at harvest.

Samples for chemical analyses were ground in a Wiley mill to pass a 2-mm screen and a 1-mm screen in a Udy mill and stored at room temperature in glass bottles. All ground samples were scanned with a NIR Systems model 6250 (scanning monochromator) near infrared reflectance spectrometer (NIRS). The computer program SUBSET was used to select calibration samples with representative spectra. Additional samples were selected at random for an independent validation set. All calibration and validation procedures followed the protocol of Windham et al. (1989). Calibration and validation samples were analyzed for crude protein (CP), acid detergent fiber (ADF), acid detergent lignin (ADL), in vitro true digestibility (IVTD), and DM. Wet chemistry procedures were according to Baethgen and Alley (1989), Van Soest and Robertson (1985) (ADF and ADL), and Goering and Van Soest (1970) (IVTD). Standard errors of calibration were 0.88% for ADF, 0.23 for ADL, 0.71 for CP, and 1.57 for IVTD. Standard errors of prediction were 1.14 for ADF, 0.35 for ADL, 0.73 for CP, and 1.76 for IVTD. Squared correlation coefficients between NIRS and laboratory values were 0.87 for ADF, 0.81 for ADL, 0.92 for CP, and 0.91 for IVTD.

A combined analysis of variance (ANOVA) across years was conducted for total yearly DM yield. Shoot density data were averaged for two harvests in 1990 and 1991, and a combined ANOVA was conducted. A combined ANOVA was also done for forage quality and morphological composition data from the initial growth harvests. When the hybrid by year interaction was significant, data were analyzed separately by year. The protected least significant difference (LSD) test was used to compare hybrid means for morphological composition, agronomic, and forage quality traits. All statistical procedures were done with the Statistical Analysis System (SAS 1988).

Results and Discussion

There was no year by hybrid interaction for DM yield or shoot density; thus 3-year averages are presented (Table 1). Dry matter yields ranged from 15,454 lb/acre for ATx623*TMTx430 to 22,085 lb/acre for ATx623*Grassl. Miller and McBee (1993) also noted lower biomass yields (12,800 lb/acre) for ATx623*TMTx430 compared with ATx623*Hegari (23,600 lb/acre) at College Station, Texas. Yield of ATx623*Rio at Stephenville (23,600 lb/acre) was very similar to that reported by Miller and McBee (1993) at College Station (17,089 lb/acre). Grassl and Hegari hybrids are tall, late maturing types frequently used in biomass and sweet sorghum hybrids. Shoot density ranged from 4.4 to 7.7 shoots/ft; however, yield was not correlated with shoot density ($r = -0.04$, $P = 0.76$).

Significant differences were observed for all forage quality traits in each year. There was no year by hybrid interaction for CP concentration (Table 2). There was a year by hybrid interaction for IVTD, ADF, and ADL; thus data were analyzed separately

Table 1. Total seasonal yield and shoot density of 12 F_1 sorghum hybrids. Yield data are averages of 3 years. Shoot densities are 2-year averages.

Hybrid	Yield	Shoot density
	lb dry matter/acre	no./ft of row
ATx623*TMTx430	15454	5.5
ATx623*Rio	17089	6.2
ATx623*EBA3	19434	7.2
ATx623*Grassl	22085	5.7
ATx623*Hegari	19989	6.3
AAtlas*Hegari	20792	7.3
A2Tx632*Hegari	16338	6.3
(A2Tx2752*BAZ9504)*Hegari	19884	6.6
(A28602*BAZ9504)*Hegari	20364	7.7
(A28602*BTx623)*Hegari	18584	5.5
(ATx378*B8106)*Hegari	18871	4.4
(ATx378*Atlas)*TMTx430	17464	7.3
Mean	18862	6.3
CV (%)	16	24.4
LSD (0.05)	2846	NS

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