Research Report

Row Spacing Effect on Forage Sorghum Yield and Quality at Maricopa, AZ, 2015

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Summary

Forage sorghum yields have been should to increase with narrow row spacing of 20 inches or less. The purpose of this research is to determine the effect of narrow row spacing on forage sorghum yield and quality in Arizona. Two row spacing (20 and 40 inch) and two forage sorghum hybrids (Great Scott and Silo 700D BMR) were evaluated in a study conducted at the University of Arizona Maricopa Agricultural Center in 2015. Row spacing had no effect on forage yield, moisture, plant height, or maturity even though light interception was greater for the closer row spacing. The only feed quality parameter affected by row spacing was lactic acid which increased with row spacing. Hybrid by row spacing interactions was detected for a few feed quality parameters. Decreasing forage sorghum row spacing from 40 to 20 inches does not appear to have an advantage based on the results of this study.

Introduction

Forage sorghum is an important crop for the dairy cattle in Arizona. This crop uses less water and nitrogen fertilizer than corn. The feed quality of forage sorghum is equal to or less than that of corn, but forage sorghum is, nevertheless, valued as a feed by the dairy industry. Forage sorghum hybrids are typically 6 - 12 ft tall, and are usually grown in 36 to 42 inch rows in Arizona. Research conducted in Texas has shown that yield increases with decreasing row spacing from 36 to 18 to 12 inches (Butler and Muir, 2003). The purpose of this research is to compare yield and quality of forage sorghum grown in 20 and 40 inch rows in Arizona.

Procedure

Row spacing for forage sorghum was evaluated in a study conducted at the University of Arizona Maricopa Agricultural Center in 2015. The soil was a Casa Grande sandy loam soil and preplant soil chemical analysis is provided in Table 1. Dual Magnum herbicide was applied preplant at a rate of 1 pint/acre and Atrazine was applied on July 22 at a rate of 2.4 pints/acre. The forage sorghum was planted at a seeding rate of 100,000 seeds/acre. The germination irrigation was applied on July 1, and subsequent irrigations applied every 10 days on average (Table 2). Nitrogen fertilizer was applied preplant and twice during the season for a total N fertilizer application of 197 lb N/acre (Table 2).

The experimental design was a randomized complete block with 2 hybrids (Silo 700D BMR and Great Scott), 2 row spacing (20 and 40 inches), and 5 blocks. The plots were 93.3 ft wide and 644 ft long for an area of 1.38 acres.

Yield and other measurements were taken on a pre-harvest sample on October 23 and at final harvest on November 19, and heading date was noted when it occurred. Light interception in the photosynthetically active range was measured six times during the season within one hour of solar noon on clear days with a Decagon Sunfleck Ceptometer by averaging 5-10 measurements from a row to the midpoint between rows. Biomass samples were obtained on October 23 from a 1 m section of row. These samples were weighed wet, chopped, and a subsample removed that was weighed wet, dried at 65 C, and weighed dry for moisture content. Forage yield was calculated and adjusted to 72% moisture content. Plant height was also measured on these plants. A similar procedure was followed on November 19 for moisture content at final harvest, but the yield was measured using truck scales from the forage obtained from a 20 ft x 557 ft swath through the middle of each plot with a commercial forage chopper. Days to maturity, or black layer of the grain, and bird damage to the grain was estimated at final harvest. The forage samples from October 23 and November 19 were submitted for estimation of quality parameters by near infrared spectroscopy (NIRS), and information from this analysis was used by MILK2006 (Schwab et al., 2003; Shaver et al., 2006) a feed quality calculator, to estimate TDN, NE_l, milk per ton, and milk per acre.

Results and Discussion

Row spacing had no effect on forage yield, moisture content, and plant height at neither final harvest on November 17 nor the sampling on October 24 (Table 4). Heading date and maturity were also not affected by row spacing. More light was intercepted by the 20 than the 40 inch rows except for the first and last date measurements were taken where no differences between row spacing was detected (Table 5). The hybrid Great Scott intercepted more light than Silo 700D BMR as measured on August 17 and September 25 due to fact that this hybrid had more leaves.

Feed quality parameters as calculated by MILK2006 were also not affected by row spacing (Table 6). However, there was a row spacing by hybrid interaction at the October 24 sampling. Milk per acre was highest at the 20-inch row spacing for Great Scott but lowest at that row spacing for Silo 700D BMR.

Row spacing did not have an effect on any feed quality parameter measured by NIRS (Tables 7 and 8) except for lactic acid which increased with row spacing at final harvest on November 17. There is several row spacing by hybrid interactions that are worth noting. At final harvest on November 17, ash and Mn were lower in the 20-inch row spacing for Great Scott, but highest at that spacing for Silo 700D BMR. At the sampling on October 24, NDF and lysine were highest at the 40-inch row spacing for Great Scott but lowest at that row spacing for Silo 700D BMR. In addition, on October 24, starch and simple sugars were highest at the 20-inch row spacing for Great Scott but lowest at that row spacing for Silo 700D BMR.

The advantage of closer row spacing is thought to be greater interception of solar radiation. In this study, we measured increased light interception by the crop in 20 compared to 40-inch row spacing, but no corresponding increase in forage yield was detected at the closer row spacing. Closer row spacing can inhibit tillering due to less light interception in the lower portion of the canopy, and this could provide an explanation for the lack of yield response at this spacing.

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References

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Table 1. Soil chemical analysis preplant for an irrigation interval trial conducted at Maricopa, AZ in 2015.

Chemical measurement	Unit	Value	Unit	Value
Total Exchange Capacity	(meq/100 g)	19.0	---	---
pH	(pH)	8.4	---	---
Organic Matter	(%)	0.6	---	---
Estimated Nitrogen Release	(lb N/acre)	26	---	---
NO_3-N	(ppm)	13.5	---	---
NH_4-N	(ppm)	8.9	---	---
S	(mg/kg)	41	---	---
P	(mg/kg)	7.5	---	---
Ca	(mg/kg)	2987	(%)	78.74
Mg	(mg/kg)	222	(%)	9.73
K	(mg/kg)	314	(%)	4.25
Na	(mg/kg)	186	(%)	4.25
Fe	(mg/kg)	3.05	---	---
Mn	(mg/kg)	0.00	---	---
Cu	(mg/kg)	4.50	---	---
Zn	(mg/kg)	7.50	---	---

Table 2. Irrigation and fertilizer schedule and amounts for an irrigation interval trial conducted at Maricopa, AZ in 2015.

Date	Irrigation amount	Fertilizer amount	Fertilizer source
		lb N/A	
07/01	9.87	102	Urea
07/12	6.18	---	---
07/23	6.73	---	---
08/02	5.43	45	UAN 32
08/10	5.51	---	---
08/23	4.08	---	---
09/01	4.49	---	---
09/10	4.56	52	UAN 32
09/18	4.82	---	---
09/27	6.01	---	---
10/07	5.09	---	---
Sum	62.77	197	---

Table 3. Precipitation (PPT) for a sorghum row spacing study conducted at Maricopa, AZ in 2015. Total precipitation received over the growing season was 3.24 inches.

July	PPT	August	PPT	September	PPT	October	PPT	November	PPT
	inches		inches		inches		inches		
3-Jul	0.04	7-Aug	0.12	3-Sep	0.02	4-Oct	0.15	4-Nov	0.07
18-Jul	0.10	9-Aug	0.46	13-Sep	0.01	6-Oct	0.08	5-Nov	0.01
31-Jul	0.26	11-Aug	0.07			16-Oct	0.21	15-Nov	0.05
		25-Aug	0.15			17-Oct	0.06	16-Nov	0.01
						18-Oct	0.96		
						20-Oct	0.29		
						21-Oct	0.01		
						29-Oct	0.09		
						30-Oct	0.02		
SUM	0.40	SUM	0.80	SUM	0.03	SUM	1.87	SUM	0.14

Table 4. Yield and other plant characteristics of forage sorghum harvested on November 17, 2015 and sampled on October 24, 2015 as affected by row spacing for a study conducted at Maricopa, AZ in 2015.

		November 17					October 24			
Hybrid	Row spacing	Yield	Moisture	Height	Days to maturity	Bird damage	Yield	Moisture	Height	Heading
	inches	T/A	%	inches		rating	T/A	%	inches	
Great Scott	20	22.2	73.3	99.6	9.00	4	20.9	82.8	92	11-Oct
	40	21.7	72.6	97.4	8.80	3	16.8	83.3	94	11-Oct
Silo 700D BMR	20	20.8	72.6	93.8	6.40	0	17.1	83.0	85	12-Oct
	40	21.5	72.7	95.4	5.60	0	16.3	83.0	92	11-Oct
Avg	Avg	21.6	72.8	96.6	7.45	2	17.8	83.0	91	11-Oct
Avg	20	21.5	73.0	96.7	7.70	2	19.0	82.9	89	11-Oct
	40	21.6	72.7	96.4	7.20	2	16.5	83.2	93	11-Oct
$LSD_{.05}$		ns	ns	ns	2.55	ns	ns	ns	ns	ns
Spacing (S)		ns	ns	ns	ns	ns	ns	ns	ns	ns
Hybrid (H)		ns	ns	ns	**	*	ns	ns	ns	ns
S x H		ns	ns	ns	ns	ns	ns	ns	ns	ns
CV (%)		6	3	7	8	130	15	2	5	0

Table 5. Interception of solar radiation by forage as affected by row spacing for a study conducted at Maricopa, AZ in 2015.

Hybrid	Row spacing	Light interception					
		Aug 3	Aug 12	Aug 17	Aug 28	Sep 25	Oct 26
	inches	% of incident					
Great Scott	20	35.6	72.4	92.2	97.6	99.2	98.1
	40	26.5	63.8	74.9	86.9	96.5	97.1
Silo 700D BMR	20	29.2	64.6	82.0	92.1	98.7	99.1
	40	20.6	51.4	59.7	86.1	92.6	97.3
Avg	Avg	28.0	63.0	77.2	90.7	96.8	97.9
Avg	20	32.4	68.5	87.1	94.9	99.0	98.6
	40	23.5	56.9	67.3	86.5	94.5	97.2
$LSD_{.05}$		ns	11.8	10.9	ns	3.0	ns
Spacing (S)		ns	**	**	*	**	ns
Hybrid (H)		ns	ns	**	ns	*	ns
S x H		ns	ns	ns	ns	ns	ns
CV (%)		51	13	10	7	2	2

Table 6. Feed quality parameters calculated by MILK2006 for forage sorghum harvested on November 17, 2015 and sampled on October 24, 2015 as affected by row spacing for a study conducted at Maricopa, AZ in 2015.

Hybrid	Row spacing	November 17				October 24			
		TDN	NE_l	Milk per ton	Milk per acre	TDN	NE_l	Milk per Ton	Milk per acre
	inches	%	Mcal/lb	lb/T	lb/A	%	Mcal/lb	lb/T	lb/A
Great Scott	20	61.3	0.587	2,534	15,716	55.6	0.523	2,108	12,325
	40	59.9	0.572	2,433	14,767	54.7	0.513	2,041	9,392
Silo 700D BMR	20	61.2	0.586	2,530	14,676	52.5	0.490	1,886	9,024
	40	63.0	0.605	2,657	16,006	56.4	0.528	2,150	9,823
Avg	Avg	61.4	0.588	2,539	15,291	54.8	0.513	2,046	10,141
Avg	20	61.3	0.587	2,532	15,196	54.1	0.507	1,997	10,675
	40	61.5	0.589	2,545	15,387	55.6	0.521	2,096	9,608
$LSD_{.05}$		ns	ns	ns	ns	ns	ns	ns	1,562
Spacing (S)		ns	ns	ns	ns	ns	ns	ns	ns
Hybrid (H)		ns	ns	ns	ns	ns	ns	ns	*
S x H		ns	ns	ns	ns	ns	ns	ns	**
CV (%)		3	3	5	8	5	6	10	11

Table 7. Feed quality parameters measured by NIRS for forage sorghum harvested on November 17 as affected by row spacing in a study conducted at Maricopa, AZ in 2015.

Hybrid	Row spacing	NDF	ADF	Protein	Fat	SIP	ADF-CP	NDF-CP	UIP	Lignin	Starch	NFC
	inches	%	%	%	%	%	%	%	%	%	%	%
Great Scott	20	47.5	31.2	6.53	2.86	34.0	0.630	1.78	31.3	8.48	19.7	40.5
	40	49.0	32.4	6.93	2.76	36.6	0.616	2.01	31.1	8.40	17.7	37.0
Silo 700D BMR	20	49.7	34.7	5.77	2.78	34.7	0.797	1.91	30.3	8.82	19.4	37.3
	40	48.4	33.3	5.98	2.80	36.7	0.752	1.77	30.1	8.45	21.3	35.5
Avg	Avg	48.6	32.9	6.30	2.80	35.5	0.699	1.87	30.7	8.53	19.5	37.6
Avg	20	48.6	33.0	6.15	2.82	34.4	0.714	1.85	30.8	8.65	19.6	38.9
	40	48.7	32.9	6.46	2.78	36.7	0.684	1.89	30.6	8.43	19.5	36.3
$LSD_{.05}$		ns	ns	0.70	ns	ns	ns	ns	ns	ns	ns	ns
Spacing (S)		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Hybrid (H)		ns	*	**	ns	ns	**	ns	ns	ns	ns	ns
S x H		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV (%)		5	6	8	9	7	16	14	4	5	12	12

Table 7 (con'd). Feed quality parameters measured by NIRS for forage sorghum harvested on November 17 as affected by row spacing in a study conducted at Maricopa, AZ in 2015.

Hybrid	Row spacing	Soluble carbs	Simple sugars	IVTDM D24	IVTDM D30	IVTDM D48	NDFD 24	NDFD 30	NDFD 48	Lysine	Methi-onine	Lactic acid
	inches	%	%	%	%	%	%	%	%	%	%	%
Great Scott	20	5.71	5.59	66.1	71.5	75.0	40.5	47.5	55.0	0.200	0.119	1.41
	40	6.28	5.69	65.1	70.5	74.0	40.1	47.1	54.6	0.225	0.129	1.72
Silo 700D BMR	20	4.50	4.16	64.6	70.1	73.5	40.7	47.8	55.3	0.200	0.116	1.24
	40	2.60	3.72	66.3	71.7	75.2	42.0	49.0	56.5	0.200	0.115	1.94
Avg	Avg	4.77	4.79	65.5	70.9	74.4	40.8	47.8	55.4	0.206	0.120	1.58
Avg	20	5.11	4.88	65.4	70.8	74.3	40.6	47.7	55.2	0.200	0.118	1.33
	40	4.44	4.71	65.7	71.1	74.6	41.1	48.1	55.6	0.213	0.122	1.83
$LSD_{.05}$		1.93	1.28	ns	ns	ns	ns	ns	ns	ns	ns	ns
Spacing (S)		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	*
Hybrid (H)		**	**	ns	ns	ns	ns	ns	ns	ns	ns	ns
S x H		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV (%)		29	19	3	2	2	5	4	4	12	8	32

Table 7 (con'd). Feed quality parameters measured by NIRS for forage sorghum harvested on November 17 as affected by row spacing in a study conducted at Maricopa, AZ in 2015.

Hybrid	Row spacing	Ash	Ca	P	Mg	S	K	Na	Cl	Fe	Mn	Cu	Zn
	inches	%	%	%	%	%	%	%	%	ppm	ppm	ppm	ppm
Great Scott	20	8.44	0.401	0.179	0.203	0.080	1.81	0.021	1.78	96	56.2	5.59	36.0
	40	9.22	0.407	0.192	0.198	0.088	1.91	0.021	1.71	130	62.5	5.91	35.7
Silo 700D BMR	20	9.01	0.350	0.172	0.125	0.080	1.77	0.022	1.24	75	69.6	5.62	36.1
	40	8.41	0.329	0.168	0.127	0.077	1.70	0.019	1.28	45	63.5	5.65	35.8
Avg	Avg	8.77	0.372	0.178	0.163	0.081	1.80	0.021	1.50	87	63.0	5.69	35.9
Avg	20	8.73	0.376	0.176	0.164	0.080	1.79	0.022	1.51	86	62.9	5.61	36.1
	40	8.82	0.368	0.180	0.163	0.083	1.81	0.020	1.50	88	63.0	5.78	35.8
$LSD_{.05}$		ns	0.028	ns	0.050	ns	0.13	ns	0.17	ns	7.4	ns	ns
Spacing (S)		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Hybrid (H)		ns	**	*	**	ns	*	ns	**	*	*	ns	ns
S x H		*	ns	ns	ns	ns	ns	ns	ns	ns	*	ns	ns
CV (%)		11	7	10	19	10	5	30	9	75	9	5	1

Table 8. Feed quality parameters measured by NIRS for forage sorghum sampled on October 24 as affected by row spacing in a study conducted at Maricopa, AZ in 2015.

Hybrid	Row spacing	NDF	ADF	Protein	Fat	SIP	ADF-CP	NDF-CP	UIP	Lignin	Starch	NFC
	inches	%	%	%	%	%	%	%	%	%	%	%
Great Scott	20	54.7	36.2	7.43	2.60	33.7	0.714	2.01	33.4	8.90	12.1	32.3
	40	55.2	36.6	8.19	2.73	34.4	0.702	2.14	33.4	9.30	11.8	29.2
Silo 700D BMR	20	59.5	41.1	7.27	2.58	32.8	0.838	2.27	33.7	9.95	10.4	25.1
	40	56.2	38.4	7.71	2.82	35.3	0.782	1.92	32.6	8.95	12.0	30.5
Avg	Avg	56.4	38.1	7.65	2.68	34.1	0.759	2.08	33.2	9.28	11.6	29.3
Avg	20	57.1	38.7	7.35	2.59	33.3	0.776	2.14	33.6	9.43	11.3	28.7
	40	55.7	37.5	7.95	2.78	34.9	0.742	2.03	33.0	9.13	11.9	29.9
$LSD_{.05}$		2.4	2.4	ns	ns	ns	0.065	ns	ns	ns	1.2	ns
Spacing (S)		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Hybrid (H)		**	**	ns	ns	ns	**	ns	ns	ns	ns	ns
S x H		*	ns	ns	ns	ns	ns	ns	ns	ns	*	ns
CV (%)		3	5	13	8	8	6	12	3	9	8	17

Table 8 (con'd). Feed quality parameters measured by NIRS for forage sorghum sampled on October 24 as affected by row spacing in a study conducted at Maricopa, AZ in 2015.

Hybrid	Row spacing	Soluble carbs	Simple sugars	IVTD MD24	IVTD MD30	IVTD MD48	NDF D24	NDF D30	NDF D48	Lysine	Methi-onine	Lactic acid	Acetic acid
	inches	%	%	%	%	%	%	%	%	%	%	%	%
Great Scott	20	9.47	7.78	62.3	67.8	71.2	39.1	46.1	53.6	0.262	0.138	2.05	0.426
	40	9.12	6.95	61.5	66.9	70.3	38.6	45.6	53.1	0.288	0.152	2.15	0.576
Silo 700D BMR	20	6.48	5.96	59.6	65.1	68.5	37.6	44.6	52.2	0.306	0.150	1.83	0.860
	40	8.79	6.82	62.6	68.1	71.5	40.5	47.6	55.1	0.266	0.140	1.76	0.828
Avg	Avg	8.46	6.88	61.5	66.9	70.4	38.9	46.0	53.5	0.281	0.145	1.95	0.673
Avg	20	7.98	6.87	61.0	66.5	69.9	38.4	45.4	52.9	0.284	0.144	1.94	0.643
	40	8.96	6.89	62.1	67.5	70.9	39.6	46.6	54.1	0.277	0.146	1.96	0.702
$LSD_{.05}$		1.91	0.70	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Spacing (S)		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Hybrid (H)		*	**	ns	ns	ns	ns	ns	ns	ns	ns	ns	*
S x H		ns	**	ns	ns	ns	ns	ns	ns	*	ns	ns	ns
CV (%)		16	7	3	3	3	5	4	4	11	10	17	38

Table 8 (con'd). Feed quality parameters measured by NIRS for forage sorghum sampled on October 24 as affected by row spacing in a study conducted at Maricopa, AZ in 2015.

Hybrid	Row spacing	Ash	Ca	P	Mg	S	K	Na	Cl	Fe	Mn	Cu	Zn
	inches	%	%	%	%	%	%	%	%	ppm	ppm	ppm	ppm
Great Scott	20	11.3	0.398	0.204	0.102	0.084	1.91	0.024	1.82	177	68.8	6.35	36.3
	40	12.5	0.408	0.226	0.108	0.088	1.87	0.026	1.83	310	71.9	6.90	36.7
Silo 700D BMR	20	12.2	0.376	0.208	0.046	0.080	1.81	0.032	1.46	236	76.4	6.56	37.2
	40	11.4	0.352	0.212	0.020	0.080	1.72	0.026	1.50	60	72.6	6.87	36.4
Avg	Avg	11.8	0.384	0.213	0.069	0.083	1.83	0.027	1.65	196	72.4	6.67	36.7
Avg	20	11.8	0.387	0.206	0.074	0.082	1.86	0.028	1.64	207	72.6	6.46	36.8
	40	12.0	0.380	0.219	0.064	0.084	1.80	0.026	1.67	185	72.3	6.89	36.6
$LSD_{.05}$		ns	0.031	ns	0.048	ns	ns	ns	0.16	ns	ns	ns	ns
Spacing (S)		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Hybrid (H)		ns	**	ns	**	*	*	ns	**	ns	ns	ns	ns
S x H		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV (%)		9	9	12	46	13	8	27	10	77	9	7	2

Table 9. Abbreviations for various phrases used to define feed quality.

Abbreviation	Phrase
ADF	Acid detergent fiber
ADF-CP	Acid detergent fiber crude protein
IVTDMD24	*In vitro* dry matter digestibility after incubation for 24 hours
IVTDMD30	*In vitro* dry matter digestibility after incubation for 30 hours
IVTDMD48	*In vitro* dry matter digestibility after incubation for 48 hours
NDF	Neutral detergent fiber
NDF-CP	Neutral detergent fiber crude protein
NDFD24	Neutral detergent fiber digestibility after incubation for 24 hours
NDFD30	Neutral detergent fiber digestibility after incubation for 30 hours
NDFD48	Neutral detergent fiber digestibility after incubation for 48 hours
NE_l	Net energy for lactation
NFC	Non-fibrous carbohydrate
SIP	Soluble intake protein
TDN	Total digestible nutrients
UIP	Undegradable intake protein
VFA	Volatile fatty acids