UC-ANR

2019 Field Research on Sorghum Grain Hybrids for California

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Introduction

Sorghum [*Sorghum bicolor* (L.) Moench] is the fifth most globally important cereal crop, ranking in total production behind rice, maize, wheat, and barley. The majority of US grain sorghum production is in Kansas and Texas, with only limited production in California; however, in the mid-1960s there were over 400,000 acres of grain sorghum planted in the state with reported yields of 70 bu acre^{-1}or 3920 lbs acre^{-1}. As California faces uncertainity about water availability sorghum could be an attractive crop for area farmers. Sorghum can remain productive under comparatively low water and nutrient conditions, and produces products such as bioenergy, food and livestock feed. Sorghum could therefore help reduce irrigation and nitrogen fertilizer use in California and be an important crop rotation cereal in many conservation tillage and farm rotational systems whilst maintaining good marketable yields. The University of California Agriculture and Natural Resources (ANR) began sorghum grain hybrid evaluation trials in 2016, and this report presents data from demonstration plots grown in three locations in 2019. Unfortunately in 2019, the linear irrigation system at KARE began to under water the field plots and this problem was not determined until after the final harvest. Plants did not express signs of drought stress throughout the growing season, but underwatering delayed flowering and tillering and harvest for yield was unobtainable.

Sorghum is an annual crop that could be both a short-term and long-term solution for California's need for a sustainable bioenergy feedstock. Sorghum can be used in all the various processes for bioenergy production; starch-to-ethanol, sugar-to-ethanol, and lignocellulose-to- bioenergy. Sorghum grain is suitable for the production of ethanol with ethanol yields per ton of grain similar to that of corn. Under ideal conditions the total grain yield of sorghum is generally less than that of corn. However, because sorghum can remain productive under lower input or higher saline conditions, it may be a more suitable grain-to-ethanol crop in California under circumstances of low irrigation and fertilization. Sorghum grain is also an important animal feed and is used in pork, poultry, and beef production. It is used in the pet food industry and can be found as a major ingredient in bird seed. More recently, the flour produced from sorghum is finding its way into many gluten-free food products. It can be steam-flaked, rolled, ground into flour, and extruded into a wide range of products.

Methods and Materials

Three seed companies provided 37 commercial grain sorghum hybrids for inclusion in these studies. Hybrids were planted in a replicated randomized block design in four 20-foot rows planted on 30-inch raised beds and were analyzed as a split-plot design, with the main plot being hybrids and the sub-plot being locations.

KARE received 7.9 inches of rain from January through the end of May and an additional 0.5 inches through the growing season. Though irrigation totals based on computer outputs indicated a total of approximately 17.71 inches of irrigation, this was determined after the trial to have been severly underreported and totals could not

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be determined. Rainfall totals from January through May prior to planting at WREC were 7.41 inches, almost twice the amount of the year before. Summer rainfall was recorded as 0.32 inches throughout the growing season. An additional 10.5 inches was applied by overhead sprinkler system over the course of the season. Rainfall totals from January through June prior to planting at UC Davis were 23.8 inches, almost 3 times greater than the previous year. An additional 2.0 inches of rainfall fell throughout the growing season. The trial was irrigated to match ET demand. Fertility applications followed similar recommendation for grain sorghums for the region.

The following is a summary of the locations where trials were located.

Trial Location:	KARE Planting, Parlier, CA
Cooperator:	UC-ANR
Previous Crop:	Winter forage (Oats)
Soil Type:	Hanford sandy loam
Plot Size:	Four, 30 inch rows by 20 ft
Replications:	3
Planting Date:	June 4, 2019
Planting Rate:	70,000 seed $acre^{-1}$
Seed Method:	Almaco 4 row plot planter
Fertilizer:	400 lbs urea ac^{-1} 46-0-0 applied pre-planting on May 31, 2019
Herbicide:	Dual Magnum at 1.3 pints per ac^{-1} as a pre-plant
Pesticide:	Sivanto 14 fl oz ac^{-1} with Latron 1956 at 5 oz ac^{-1} August 8, 2019
Irrigation:	Undetermined
Grain Harvest Date:	No harvest

Trial Location:	Westside Research and Extension Center, Five Points, CA
Cooperator:	UC-ANR
Previous Crop:	Fallow
Soil Type:	Panoche clay loam
Plot Size:	Four, 30 inch rows by 17 ft
Replications:	3
Planting Date:	June 12, 2019
Planting Rate:	70,000 seed $acre^{-1}$
Seed Method:	Almaco 4 row plot planter
Fertilizer:	100 lbs N $acre^{-1}$
Herbicide:	Dual Magnum 24 oz/ac as pre-emergent, Clarity 8oz and Prowl-H_20 at 32 oz ac^{-1} as needed
Pesticide:	3 applications of Sivanto Prime 14oz ac^{-1}
Irrigation:	Overhead irrigation system – see narrative for amounts
Grain Harvest Date:	Plots harvested with Almaco SPC 40 Plot Combine on October 25, 2019

Trial Location:	UC Davis Research Station, Davis, CA
Cooperator:	UC-ANR
Previous Crop:	Fallow
Soil Type:	Yolo loam
Plot Size:	Four, 30 inch rows by 20 ft
Replications:	3
Planting Date:	June 5, 2019
Planting Rate:	70,000 seed $acre^{-1}$
Seed Method:	Wintersteiger Self Propelled Drill Planter
Fertilizer:	A total of 100 lbs N was applied
Herbicide:	Dual Magnum as a pre-emergent on June 11
Pesticide:	None
Irrigation:	Matched ET
Grain Harvest Date:	Plots harvested with Almaco SPC 40 Plot Combine on October 28, 2019

Data Collected:

- Emergence (%) calculated by number of seed planted divided by stand counts
- Vigor (1-5)
- Plant height (cm)
- Panicle length (cm)
- Panicle Exsertion (cm)
- Yield (lbs ac^{-1})
- Seed Moisture Content at Harvest.
- 1000 seed weight (g)
- Data was analyzed using the SAS statistical package.

Results

No major pest or disease were observed at any of the locations, though KARE and WREC were treated for the presence of Sugarcane Aphids, which have been shown to cause severe damage to grain sorghum as reported by the United Sorghum Checkoff Program (www.sorghumcheckoff.com).

Early Agronomic Data

Flowering dates reflected the various maturities available in the grain sorghum hybrids being evaluated in the state. Flowering dates ranged from early, 57.7 days after planting (Dyna-Gro M54GR24), to late flowering at 93.7 days (Gayland Ward 19017) (Table 1). Davis average 63 days to flowering. The later flowering dates can be attributed to early pre-flowering drought stress. Though the plants did not exhibit characteristic signs of pre-flowering drought stress, on manifestation of early drought is delayed flowering, as was observed at KARE. This was also reflected in much shorter plant height, panicle lengths and exsertions observed at KARE (Table 1).

Plant and Panicle measurements and Yield Data

Table 2 shows % lodging, yield data reported as bu ac^{-1} and 1000 seed weight. There was no lodging recorded at either KARE or WREC, while Davis did record some lodging. The highest lodging was observed in Dyna-Gro Dual Forage SCA at 21.1%. Some of this lodging could be attributed to the amount of moisture available in

the fields at Davis, which saw much greater winter rainfall that normal. Davis had much higher grain yields and 1000 seed weigths than WREC. Davis average yield was 160.3 bu ac^{-1}, whereas WREC average yield was 108.0 bu ac^{-1}. The highest yielding hybrid was Dyna-Gro's M71GR04 at 169.28 bu ac^{-1}.

Discussion

Water played a significant role in the yields of the grain sorghum this year, with KARE suffering from a issue with the linear irrigation system that caused severe yield reductions and unharvestabl yields. The sorghum plants did tiller and sent out secondary panicles but flowered so late in the season that plants did not have the opportunity to fully mature. Yields were much higher in Davis which may have been a reflection of the available water from greater winter rainfalls. The high yield potential and the marketability of sorghum grain into various market channels would work well in conservation tillage practices and as a rotation crop for other annual crops, such as cotton, canning tomatoes, or other vegetable crops or as a viable crop in a conservation till program here in the Valley.

Table 1. Various agronomic characteristics for grain sorghum hybrids grown in 3 locations in California in 2019, KARE, WREC, and the UC Davis Research Station.

Hybrid Information			**Agronomic Measurements***			
Entry	**Company**	**Hybrid**	**DTF**[1]	**Plant Height (cm)**	**Exsertion (cm)**	**Panicle Length (cm)**
1	Dyna-Gro	Dual Forage SCA	84.5 c	136.6 a	8.5 d-j	21.33 op
2	Dyna-Gro	M54GR24	57.7 o	92.8 p	10.7 b-g	24.06 j-o
3	Dyna-Gro	M60GB31	63.8 j-o	108.7 k-o	5.9 g-k	25.44 g-n
4	Dyna-Gro	M69GB38	83.2 c	112.4 j-n	10.0 c-h	22.56 m-p
5	Dyna-Gro	M71GR04	85.7 bc	130.1 a-c	5.6 h-k	22.39 n-p
6	Dyna-Gro	M74GB17	72.0 f-i	113.9 i-m	6.7 g-k	26.56 d-k
7	Dyna-Gro	GX19981	74.2 d-f	112.2 j-o	3.7 k	20.44 p
8	Dyna-Gro	GX18991	73.7 d-f	124.4 c-f	3.9 jk	23.44 k-p
9	Sorghum Partners-SW Seed	SP74M21	82.2 c	112.6 j-n	14.8 b-g	28.50 c-g
10	Sorghum Partners-SW Seed	SP7715	92.3 ab	125.6 c-e	6.3 g-k	32.06 ab
11	Sorghum Partners-SW Seed	SP68M57	58.3 no	104.6 no	5.9 g-k	29.56 a-d
12	Sorghum Partners-SW Seed	SP74C40	79.0 c-f	113.9 i-m	3.8 jk	27.94 c-i
13	Sorghum Partners-SW Seed	NK 8828	71.3 g-i	112.9 j-m	7.7 e-k	29.00 c-f
14	Gayland Ward Seed	18035	60.2 m-o	115.3 g-l	10.3 b-h	28.00 c-i
15	Gayland Ward Seed	18036	61.2 l-o	122.3 c-h	12.0 b-f	28.22 c-h
16	Gayland Ward Seed	18049	59.7 m-o	124.4 c-f	9.7 c-h	25.00 h-n
17	Gayland Ward Seed	18057	63.2 k-o	104.3 o	10.0 c-h	26.06 e-l
18	Gayland Ward Seed	18068	64.0 j-o	114.0 i-m	15.1 b	29.22 b-e
19	Gayland Ward Seed	18071	69.8 g-k	134.6 ab	4.8 i-k	27.78 c-i
20	Gayland Ward Seed	18083	66.3 h-m	123.3 c-g	12.6 b-d	22.83 l-p
21	Gayland Ward Seed	18084	61.2 l-o	116.2 g-k	20.6 a	27.11 d-j
22	Gayland Ward Seed	18087	62.3 l-o	125.8 c-e	20.2 a	26.00 e-l

Table 1. continued.

Hybrid Information			Agronomic Measurements*			
Entry	**Company**	**Hybrid**	**DTF[1]**	**Plant Height (cm)**	**Exsertion (cm)**	**Panicle Length (cm)**
23	Gayland Ward Seed	18092	62.8 k-o	114.8 h-m	8.8 d-i	24.83 i-n
24	Gayland Ward Seed	18102	72.7 e-h	119.7 d-j	5.6 h-k	24.67 i-o
25	Gayland Ward Seed	18153	80.7 cd	126.6 b-d	3.8 jk	26.56 d-k
26	Gayland Ward Seed	18273	67.8 g-l	117.2 f-j	7.9 d-k	25.78 f-m
27	Gayland Ward Seed	18274	59.2 no	108.8 k-o	7.2 f-k	30.94 a-c
28	Gayland Ward Seed	18290	61.8 l-o	106.7 m-o	6.2 g-k	24.00 j-o
29	Gayland Ward Seed	18291	66.3 h-m	112.8 j-m	9.0 d-i	26.67 d-k
30	Gayland Ward Seed	18350	63.0 k-o	116.0 g-k	5.9 g-k	29.89 a-d
31	Gayland Ward Seed	18567	82.8 c	118.3 e-j	6.4 g-k	28.83 b-f
32	Gayland Ward Seed	19014	65.2 i-n	125.7 c-e	9.3 c-i	25.22 g-n
33	Gayland Ward Seed	19016	79.5 c-e	119.6 d-j	8.4 d-k	32.78 a
34	Gayland Ward Seed	19017	93.7 a	129.8 a-c	8.4 d-k	32.00 ab
35	Gayland Ward Seed	19023	70.5 g-i	130.1 a-c	13.9 bc	26.89 d-j
36	Gayland Ward Seed	19024	61.5 l-o	107.4 l-o	12.2 b-e	26.72 d-k
37	Gayland Ward Seed	19152	69.5 g-k	121.7 d-i	4.7 i-k	27.44 d-i
	Means **CV**		**70.3** **8.76**	**117.73** **7.36**	**8.82** **58.24**	**26.67** **13.56**
	Location					
	KARE		**77.64 a**	**91.2 c**	**4.10 b**	**19.2 c**
	UC Davis		**63.04 b**	**116.4 b**	**11.7 a**	**31.6 a**
	WREC		**-**	**145.7 a**	**10.6 a**	**29.2 b**

*Means followed by the same letter do not significantly differ using LSD (P=0.05); [1]DTF=days to 50% flowering.

Table 2. Various agronomic and yield characteristics for grain sorghum hybrids grown in 3 locations in California in 2019, KARE, WREC, and the UC Davis Research Station.

Hybrid Information			**Agronomic Measurements***		
Entry	**Hybrid**	**Company**	**Lodging %**	**Yield Bushel ac^{-1}**	**1000 seed weight (g)**
1	Dual Forage SCA	Dyna-Gro	21.1	144.32	24.09 b-d
2	M54GR24	Dyna-Gro	0	132.10	20.67 ij
3	M60GB31	Dyna-Gro	0	126.46	20.08 j
4	M69GB38	Dyna-Gro	11.1	147.97	20.61 ij
5	M71GR04	Dyna-Gro	0	169.28	22.20 d-i
6	M74GB17	Dyna-Gro	0	139.22	23.49 d-f
7	GX19981	Dyna-Gro	0	145.39	23.00 d-h
8	GX18991	Dyna-Gro	0	128.49	23.48 c-g
9	SP74M21	Sorghum Partners-SW Seed	0	125.80	26.74 a
10	SP7715	Sorghum Partners-SW Seed	0	142.51	23.05 d-g
11	SP68M57	Sorghum Partners-SW Seed	0	138.58	22.06 d-j
12	SP74C40	Sorghum Partners-SW Seed	0	126.27	23.16 d-g
13	NK 8828	Sorghum Partners-SW Seed	3.3	124.22	21.60 f-j
14	18035	Gayland Ward Seed	2.8	147.85	22.85 d-h
15	18036	Gayland Ward Seed	5.6	127.02	23.44 c-g
16	18049	Gayland Ward Seed	0	138.63	21.62 f-j
17	18057	Gayland Ward Seed	0	134.12	21.45 g-j
18	18068	Gayland Ward Seed	0	139.24	21.59 f-j
19	18071	Gayland Ward Seed	0	102.50	23.70 b-f
20	18083	Gayland Ward Seed	12.8	115.29	23.64 b-f
21	18084	Gayland Ward Seed	0	105.80	24.08 b-d

Table 2. continued.

Hybrid Information			Agronomic Measurements*		
Entry	**Hybrid**	**Company**	**Lodging %**	**Yield Bushel ac^{-1}**	**1000 seed weight (g)**
22	18087	Gayland Ward Seed	12.8	133.25	25.30 a-c
23	18092	Gayland Ward Seed	0	135.97	21.46 g-j
24	18102	Gayland Ward Seed	0	165.13	21.98 d-i
25	18153	Gayland Ward Seed	0	120.43	23.32 c-g
26	18273	Gayland Ward Seed	0	124.44	20.15 ij
27	18274	Gayland Ward Seed	0	120.88	20.89 h-j
28	18290	Gayland Ward Seed	0	138.39	20.10 ij
29	18291	Gayland Ward Seed	0	126.92	23.20 c-g
30	18350	Gayland Ward Seed	0	127.60	23.13 d-g
31	18567	Gayland Ward Seed	11.1	165.25	23.38 c-g
32	19014	Gayland Ward Seed	0	99.72	23.88 b-e
33	19016	Gayland Ward Seed	0	125.26	23.99 b-e
34	19017	Gayland Ward Seed	0	146.88	23.07 d-g
35	19023	Gayland Ward Seed	0	168.62	25.73 ab
36	19024	Gayland Ward Seed	0	113.31	21.59 f-j
37	19152	Gayland Ward Seed	0	149.74	21.95 e-j
Mean			**2.18**	**134.06**	**22.70**
CV			**540.28**	**22.60**	**8.12**
Location					
KARE			**0.00 b**	**-**	**-**
UC Davis			**6.53 a**	**160.37 a**	**23.50 a**
WREC			**0.00 b**	**108.00 b**	**21.89 b**

*Means followed by the same letter do not significantly differ using LSD (P=0.05)