UC-ANR

2020 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. Sorghum is not new to California; it was first introduced to the state in the late 1800s as a drought tolerant forage for animal feed. Sudangrass, a sorghum type, is routinely grown in various parts of the state for hay production, while forage sorghums have been grown for dairy feed. Forage sorghums, which tend to use much less water than other forage crops, took on some relevance over the last several years because of the extended drought and water issues facing forage producers. At one time, the primary use for grain sorghum was for animal feed for the dairy and beef industries, but its use has expanded into several different arenas over the years. It is used in the pet-food industry, the pork, poultry and bird seed industries, in the renewable fuels industry, and more recently into food systems. Gluten-free beers and food have seen an increase of sorghum use in the last several years, while speciality "ancient grain" uses have expanded. Some grain sorghums have high anti-oxidant tannins that have become specialty ingredients in the health-food market. There was some renewed interest in grain sorghum in the California with the ethanol industry, as they would have received a credit for using sorghum as a feedstock for ethanol conversion. There has also been some interest in grain sorghum as a potential flour substitute in gluten-free food products. However, sorghum flour will probably not gain the acceptance it once had back in the mid-1960s, when over 400,000 acres of grain sorghum was planted in the state, primarily as a rotational crop for crops such as cotton. In the mid-1960s, yield in the state were approximately double that of national sorghum yield at 70 bu acre^{-1}or 3920 lbs acre^{-1}. Hybrid grain sorghums had only been introduced to the United States in the late 1950s and only started to have a real impact on yields in the late 1960s.

Sorghum can remain productive under comparatively low water and nutrient conditions. 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 2020. The 2020 growing season was impacted by poor air quality and smoke from the various fires that impacted the state over the summer, and plant growth and yields seemed to have been affected by these poor quality air and pollution issues.

Sorghum is an annual crop that could be both a short-term and long-term solution for California's need for a sustainable crop rotation for farms to breakup disease and insect life-cycles, add biomass back to soils, recycle nutrients and water deeper in the soil profile, and improve soil structure and health. It can be steam-flaked, rolled, ground into flour, and extruded into a wide range of products.

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Methods and Materials
Four seed companies provided 43 commercial grain sorghum hybrids for inclusion in these studies. Hybrids were planted in a replicated randomized complete 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.

Kearney Agricultural Research and Extension Center (KARE) received 4.9 inches of rain from January through the end of May. Irrigation totals were 17.89 inches of irrigation applied through a linear irrigation system. Rainfall totals from January through May prior to planting at West Side Research and Extension Center (WSREC) were 4.05 inches. Summer rainfall was recorded as 0.93 inches throughout the growing season. An additional 14.5 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 3.8 inches, 20 inches lower than the previous year. An additional 0.1 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 1, 2020
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 1/3 pints per ac^{-1} as a pre-plant; Gramoxone at 48 oz per ac^{-1}, Maestro 4 EC at .5 pint per ac^{-1}
Pesticide:	Sivanto Prime at 14 fl oz per ac^{-1}
Irrigation:	Overhead irrigation system – see narrative for amounts
Grain Harvest Date:	Plots harvested on October 27, 2020 with Almaco SPC 40 Plot Combine

Trial Location:	WSREC, Five Points, CA
Cooperator:	UC-ANR
Previous Crop:	Sorghum
Soil Type:	Panoche clay loam
Plot Size:	Four, 30 inch rows by 20 ft
Replications:	3
Planting Date:	June 3, 2020
Planting Rate:	70,000 seed $acre^{-1}$
Seed Method:	Almaco 4 row plot planter
Fertilizer:	Starter 100 lbs $acre^{-1}$ 11-52-00 pre-plant and layby of 190 lbs $acre^{-1}$
Herbicide:	Dual Magnum 24 oz/ac as pre-emergent, Clarity 8oz ac^{-1} as a layby

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 November 2, 2020
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:	Starter 20 lbs 8-28-6 starter fertilizer and layby of 175 lbs $acre^{-1}$ (46-0-0)
Herbicide:	Dual Magnum as a pre-emergent
Pesticide:	None
Irrigation:	Matched ET, Furrow Irrigation
Grain Harvest Date:	Plots harvested with Almaco SPC 40 Plot Combine on October 26, 2020

Data Collected:

- Emergence (%) calculated by number of seed planted divided by stand counts
- Plants per acre
- Days to flowering
- Plant height (cm)
- Panicle length (cm)
- Panicle exsertion (cm)
- Yield (bu ac^{-1})
- Seed moisture content at harvest.
- 1000 seed weight (g)
- Data was analyzed using the SAS statistical package.

Results

No major pests or diseases were observed at any of the locations, though KARE and WSREC 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-, 57.6 days after planting (Lockwood LS-55), to late-flowering at 88.6 days (Gayland Ward 19017) (Table 1). As in 2019, Davis average shorter days to flowering than either WSREC or KARE. Flowering was earlier this year compared to the previous year. This may be a reflection of the poor air quality and smoke filled skies that were representative of this past summer. Plants seemed to be earlier and less vigorous than previous years. Average plant heights, exsertion and panicle lengths were shorter than the

previous year. Hybrids averaged 106 cm in height (Table 1), with a range of 81.3 cm (Dyna-Gro M54GR24) to a high of 132.2 cm (Gayland Ward 18096).

Plant and Panicle measurements and Yield Data

Table 2 shows plants per acre, yield data reported as bu ac^{-1} and 1,000 seed weight. There was no lodging recorded at any of the sites this year. Davis had much higher grain yields and 1,000 seed weigths than KARE or WSREC. Davis average yield was 117.47 bu ac^{-1} roughly 25% lower than the previous year. In years past, KARE, with its' sandy loam soils, had lower average yields, but this year WSREC had the lowest average yields. The highest yielding hybrid was Gayland Ward's 19023 at 142.73 bu ac^{-1}.

Discussion

In the past, rainfall and irrigation impacted yield and growth observations of the sorghum hybrids grown at the three sites. This year, with low winter rainfalls and very poor air quality and heavy smoke, air quality seemed to play a greater role in impacting both agronomic and yield characteristics of the plants grown and harvested. Yields again were higher in Davis, but there is good potential for high yielding sorghums in both the sandy-loam soils of KARE and the clay-loam soils of WSREC. Next year's plantings may again be impacted by poor air quality and smoke if trends towards greater and longer fire seasons continue in the state. 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 2020 KARE, WSREC, and the UC Davis Research Station.

Hybrid Information			Agronomic Measurements[1]				
Entry	Company	Hybrid	Emerg[2]	DTF[3]	Plant Height (cm)	Exsertion (cm)	Panicle Length (cm)
1	Dyna-Gro Seed	M54GR24	77.18 a-g	59.6 kl	81.3 h	10.7 a-f	21.8 c-f
2	Dyna-Gro Seed	M59GB94	80.16 a-f	63.8 h-k	98.6 d-h	7.8 a-g	22.1 c-f
3	Dyna-Gro Seed	M60GB31	68.72 c-i	64.2 h-k	101.8 c-h	7.2 b-g	23.1 b-f
4	Dyna-Gro Seed	M62GB77	73.15 a-h	63.2 i-k	98.4 d-h	6.8 b-g	24.7 a-e
5	Dyna-Gro Seed	M69GR88	75.20 a-h	76.2 cd	108.0 a-g	5.9 c-g	19.7 d-f
6	Dyna-Gro Seed	GX19981	81.75 a-d	68.7 e-i	106.4 b-h	6.2 c-g	20.0 d-f
7	Dyna-Gro Seed	M71GR91	80.75 a-e	69.9 e-g	117.9 a-d	9.3 a-g	24.7 a-e
8	Dyna-Gro Seed	M72GB71	74.21 a-h	68.6 e-i	109.9 a-g	10.6 a-f	24.7 a-e
9	Dyna-Gro Seed	M74GB17	64.29 e-i	69.2 e-h	110.8 a-g	4.9 d-g	25.7 a-e
10	S & W Seed	SP68M57	63.76 f-i	61.3 kl	93.7 d-h	8.7 a-g	25.1 a-e
11	S & W Seed	SP74M21	63.76 f-i	72.1 d-f	107.6 a-g	7.2 b-g	28.1 a-d
12	S & W Seed	SP74C40	68.32 d-i	73.8 de	110.1 a-g	5.7 c-g	27.1 a-d
13	S & W Seed	SP7715	55.87 i	88.2 a	109.9 a-g	7.2 b-g	26.5 a-d
14	S & W Seed	NK8828	66.27 d-i	70.9 d-f	109.1 a-g	8.6 a-g	25.7 a-e
15	Lockwood seed	LS-55	72.55 a-h	57.6 l	95.0 d-h	14.2 a-d	23.4 b-f
16	Gayland Ward Seed	18057	76.25 a-g	64.1 h-k	101.5 c-h	15.0 a-c	25.0 a-e
17	Gayland Ward Seed	19016	62.92 g-i	75.7 cd	113.2 a-f	4.0 e-h	31.0 ab
18	Gayland Ward Seed	19017	58.81 hi	88.6 a	128.2 ab	10.1 a-f	30.2 a-c
19	Gayland Ward Seed	18072	74.88 a-h	75.8 cd	105.8 b-h	1.6 f-h	22.4 c-f
20	Gayland Ward Seed	18096	79.46 a-f	81.2 bc	132.2 a	5.0 d-g	24.8 a-e
21	Gayland Ward Seed	18567	84.82 a-c	82.7 b	124.8 a-c	7.0 b-g	27.0 a-d
22	Gayland Ward Seed	18004	78.57 a-g	69.0 e-h	111.0 a-g	16.0 ab	23.0 b-f
23	Gayland Ward Seed	18005	72.62 a-h	71.0 d-f	98.0 d-h	13.0 a-e	20.0 d-f
24	Gayland Ward Seed	18035	75.60 a-g	67.0 f-j	102.0 c-h	5.0 d-g	26.0 a-e
25	Gayland Ward Seed	18036	75.00 a-h	65.0 g-k	113.0 a-f	13.0 a-e	26.0 a-e
26	Gayland Ward Seed	18039	82.74 a-d	72.0 d-f	99.0 d-h	6.0 c-g	22.0 c-f
27	Gayland Ward Seed	18040	79.17 a-g	72.0 d-f	108.0 a-g	17.0 a	22.0 c-f
29	Gayland Ward Seed	18063	73.81 a-h	64.0 h-k	91.0 f-h	14.0 a-d	21.0 d-f
31	Gayland Ward Seed	18093	70.83 b-i	65.0 g-k	92.0 e-h	10.0 a-f	20.0 d-f
32	Gayland Ward Seed	18094	77.98 a-g	64.0 h-k	95.0 d-h	13.0 a-e	21.0 d-f
34	Gayland Ward Seed	18102	80.36 a-e	72.0 d-f	103.0 b-h	0.0 gh	27.0 a-d
35	Gayland Ward Seed	18103	86.31 ab	71.0 d-f	110.0 a-g	15.0 a-c	21.0 d-f
36	Gayland Ward Seed	18232	82.74 a-d	71.0 d-f	100.0 c-h	9.0 a-g	24.0 b-f
37	Gayland Ward Seed	18350	81.55 a-d	63.0 j-l	87.0 gh	0.0 h	33.0 a
38	Gayland Ward Seed	18362	87.50 a	71.0 d-f	96.0 d-h	10.0 a-f	16.0 f
40	Gayland Ward Seed	19001	70.83 b-i	69.0 e-h	107.0 a-g	10.0 a-f	27.0 a-d
41	Gayland Ward Seed	19009	75.00 a-h	63.0 j-l	87.0 gh	15.0 a-c	20.0 d-f

Table 1, continued.

Hybrid Information			Agronomic Measurements				
Entry	**Company**	**Hybrid**	**Emerg**	**DTF**	**Plant Height (cm)**	**Exsertion (cm)**	**Panicle Length (cm)**
44	Gayland Ward Seed	19023	75.60 a-g	71.0 d-f	111.0 a-g	13.0 a-e	25.0 a-e
45	Gayland Ward Seed	20132	75.00 a-h	72.0 d-f	97.0 d-h	6.0 c-g	22.0 c-f
46	Gayland Ward Seed	20133	77.98 a-g	71.0 d-f	117.0 a-e	14.0 a-d	25.0 a-e
47	Gayland Ward Seed	20312	79.76 a-f	65.0 g-k	87.0 gh	12.0 a-e	18.0 ef
48	Gayland Ward Seed	20313	73.21 a-h	71.0 d-f	102.0 c-h	6.0 c-g	25.0 a-e
	Means **CV**		**70.79** **11.11**	**71.65** **3.69**	**106.80** **11.43**	**8.17** **55.27**	**24.88** **16.26**
	Location						
	KARE		**71.89 b**	**72.5 a**	**103.2 b**	**7.9 b**	**23.4 b**
	UC Davis		**60.74 c**	**71.8 a**	**102.0 b**	**12.6 a**	**27.8 a**
	WSREC		**79.29 a**	**70.4 b**	**116.8 a**	**4.2 c**	**24.1 b**

[1]Means followed by the same letter do not significantly differ using LSD (P=0.001); [2]Emerg=Emergence % based on stand count of 168 seed planted per row; [3]DTF=days to 50% flowering.

Table 2. Various agronomic and yield characteristics for grain sorghum hybrids grown in 3 locations in California in 2020, KARE, WSREC, and the UC Davis Research Station.

Hybrid Information			Agronomic Measurements[1]		
Entry	Company	Hybrid	Plant per ac	Yield bu ac^{-1}	1000 seed Weight (g)
1	Dyna-Gro Seed	M54GR24	56483 a-g	73.31 c-k	29.18 b-i
2	Dyna-Gro Seed	M59GB94	58661 a-f	108.21 a-g	33.153 a-d
3	Dyna-Gro Seed	M60GB31	50288 c-i	101.44 a-i	33.542 a-c
4	Dyna-Gro Seed	M62GB77	53530 a-h	95.73 a-j	31.923 a-f
5	Dyna-Gro Seed	M69GR88	55031 a-g	86.31 b-j	31.949 a-f
6	Dyna-Gro Seed	GX19981	59822 a-d	85.43 b-j	32.943 a-d
7	Dyna-Gro Seed	M71GR91	59096 a-e	122.7 a-c	32.856 a-e
8	Dyna-Gro Seed	M72GB71	54305 a-h	101.98 a-h	33.886 a-c
9	Dyna-Gro Seed	M74GB17	47045 e-i	92.45 a-j	31.789 a-f
10	S & W Seed	SP68M57	46658 f-i	75.83 c-k	31.616 a-g
11	S & W Seed	SP74M21	46658 f-i	88.41 a-j	34.224 a-c
12	S & W Seed	SP74C40	49997 d-i	92.31 a-j	33.011 a-d
13	S & W Seed	SP7715	40887 i	106.92 a-g	31.503 a-g
14	S & W Seed	NK8828	48497 d-i	86.5 b-j	31.26 a-g
15	Lockwood seed	LS-55	53095 a-h	92.62 a-j	30.991 a-h
16	Gayland Ward Seed	18057	55800 a-g	88.5 a-j	33.579 a-c
17	Gayland Ward Seed	19016	46043 g-i	72.87 c-k	32.39 a-f
18	Gayland Ward Seed	19017	43037 hi	49.29 h-k	32.228 a-f
19	Gayland Ward Seed	18072	54798 a-h	46.48 i-k	33.222 a-d
20	Gayland Ward Seed	18096	58153 a-f	57.03 g-k	35.85 ab
21	Gayland Ward Seed	18567	62073 a-c	63.25 e-k	37.088 a
22	Gayland Ward Seed	18004	57499 a-g	91.86 a-j	30.52 a-h
23	Gayland Ward Seed	18005	53143 a-h	61.37 f	18.98 k
24	Gayland Ward Seed	18035	55321 a-g	103.52 a-h	24.13 h-k
25	Gayland Ward Seed	18036	54886 a-h	137.59 ab	29.45 b-i
26	Gayland Ward Seed	18039	60548 a-d	27.97 k	21 jk
27	Gayland Ward Seed	18040	57935 a-g	86.87 b-j	27.12 c-j
29	Gayland Ward Seed	18063	54014 a-h	79.01 c-k	24.41 g-k
31	Gayland Ward Seed	18093	51836 a-h	103.14 a-h	28.79 b-i
32	Gayland Ward Seed	18094	57064 a-g	71.48 c-k	29.78 a-i
34	Gayland Ward Seed	18102	58806 a-e	65.63 d-k	27.37 c-j
35	Gayland Ward Seed	18103	63162 ab	44.36 jk	26.02 d-k
36	Gayland Ward Seed	18232	60548 a-d	40.84 jk	27.17 c-j
37	Gayland Ward Seed	18350	59677 a-d	61.89 f-k	25.46 f-k
38	Gayland Ward Seed	18362	64033 a	115.47 a-f	22.46 i-k
40	Gayland Ward Seed	19001	51836 b-i	118.98 a-d	30.94 a-h
41	Gayland Ward Seed	19009	54886 a-h	80.47 c-k	29.38 b-i

Table 2, continued.

Hybrid Information			Agronomic Measurements		
Entry	**Company**	**Hybrid**	**Plant per ac**	**Yield bu ac^{-1}**	**1000 seed Weight (g)**
44	Gayland Ward Seed	19023	55321 a-g	142.73 a	29.43 b-i
45	Gayland Ward Seed	20132	54886 a-h	59.3 g-k	28.08 c-j
46	Gayland Ward Seed	20133	57064 a-g	116.99 a-e	32.42 a-f
47	Gayland Ward Seed	20312	58370 a-f	54.66 g-k	29.28 b-i
48	Gayland Ward Seed	20313	53579 a-h	94.01 a-j	25.55 e-k
	Means		**51808.17**	**87.46**	**32.03**
	CV		**11.12**	**30.00**	**10.97**
	Location				
	KARE		**52606.0 b**	**84.39 b**	**28.87 b**
	UC Davis		**44451.9 c**	**117.47 a**	**22.10 c**
	WSREC		**58024.7 a**	**62.28 c**	**46.45 a**

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