UC-ANR
2018 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}. California yields were approximately double the national average. Sorghum is an old crop in California, with the United States Department of Agriculture (USDA) introducing a tall, drought tolerant forage type sorghum to the state in the late 1880s as an animal feed. For most of the world, sorghum is used as a staple food crop and more recently has been used in gluten-free food products here in the United States. Sorghum is an attractive crop for the state — 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 2018. These reports, along with helpful information on other research trials and management strategies, are available on the ANR website sorghum.ucanr.edu.

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 being 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 - 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.

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Methods and Materials

Two seed companies provided 15 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. Irrigation was applied using furrow irrigation at Kearney Agricultural Research and Extension Center (KARE) and a combination of overhead sprinklers and flood irrigation at the Westside Research and Extension Center (WREC) and at the UC Davis Research farm. Fertility applications followed similar recommendation for grain sorghums for the region. The 2018 growing season was drier than the previous year, with rainfall totals from January through May at approximately 75% of normal for all trial locations. Trials at KARE, WREC and DAVIS were irrigated as needed and according to ET demands of the crop at the various locations.

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 5, 2018
Planting Rate:	70,000 seed $acre^{-1}$
Seed Method:	Almaco 4 row plot planter
Fertilizer:	184 lbs N ac^{-1} 46-0-0, 11 lbs N ac^{-1} and 52 lbs PO^{3-} ac^{-1} 11-52-0, and 200 lbs K_2O ac^{-1} 0-0-50 applied pre-planting on June 4
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 1
Irrigation:	18.44 inches applied by furrow irrigation
Grain Harvest Date:	Plots harvested with Almaco SPC 40 Plot Combine on October 19th, 2018

Trial Location:	Westside Research and Extension Center, Five Points, CA
Cooperator:	UC-ANR
Previous Crop:	Barley (December 2016-April 2017)
Soil Type:	Panoche clay loam
Plot Size:	Four, 30 inch rows by 17 ft
Replications:	3
Planting Date:	June 21, 2018
Planting Rate:	70,000 seed $acre^{-1}$
Seed Method:	Almaco 4 row plot planter
Fertilizer:	200 lbs N ac^{-1} 46-0-0 on July 17, 2018
Herbicide:	Dual Magnum at 24 oz per ac^{-1} as a pre-plant on June 8, Clarity 8oz+Prowl H20 32 oz $^{ac-1}$ July 17, 2018
Pesticide:	Sivanto Prime 14 fl oz ac^{-1} August 21, August 31, September 13, 2018
Irrigation:	3.5 inches applied by sprinkler for germination, additional 15.1 inches applied by furrow irrigation

Grain Harvest Date:	Plots harvested with Almaco SPC 40 Plot Combine on October 29th, 2018

Trial Location:	UC Davis Research Station, Davis, CA
Cooperator:	UC-ANR
Previous Crop:	Safflower
Soil Type:	Yolo loam
Plot Size:	Four, 30 inch rows by 20 ft
Replications:	3
Planting Date:	June 11, 2018
Planting Rate:	70,000 seed $acre^{-1}$
Seed Method:	Wintersteiger Self Propelled Drill Planter
Fertilizer:	18 lbs N ac^{-1} 8-28-6 on June 11, 182 lbs N ac^{-1} 8-28-6 on July 12.
Herbicide:	Dual Magnum as a pre-emergent on June 11
Pesticide:	Sivanto at 7 oz/A on September 21, 2018
Irrigation:	Matched ET
Grain Harvest Date:	Plots harvested with Almaco SPC 40 Plot Combine on October 25th, 2018

Data Collected:

1. Emergence (%) calculated by number of seed planted divided by stand counts
2. Vigor (1-5)
3. Plant height (cm)
4. Panicle length (cm)
5. Panicle Exsertion (cm)
6. Yield (lbs ac^{-1})
7. Seed Moisture Content at Harvest.
8. 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 all three 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

Emergence data ranged from a low of 59.72% in the hybrid M74GB17 from Dyna-Gro to a high of 80.82% in the hybrid DKS47-07 from Monsanto (Table 1). Emergence data was calculated by calculating the percentage of plants that emergence after planting compared to the actual number of seed planted. KARE had the highest yields as well as the highest emergence percentage (Tables 1 and 2). Emergence can be a reflection of seed germination or quality, soil and moisture stress or other biotic stresses. Flowering dates reflected the various maturities available in the grain sorghum hybrids being evaluated in the state. Flowering dates ranged from early, 57.9 days after planting with Monsanto DKS38-16, to late flowering at 80.0 days in the M73GR55 hybrid from Dyna-Gro (Table 1). WREC was the quickest to flower and the last to be harvested giving the grain the most time to develop, which may have helped make up for its low emergence.

Plant and Panicle measurements and Yield Data

Table 2 shows plant height, panicle measurements yield data and 1000 seed weight. As with the earlier agronomic data, location had a significant impact on these various measurements. Plant heights ranged from 108.3 cm (Dyna-Gro's GX17962) to a high of 136.3 cm (Dyna-Gro's Dual Forage SCA). Average yields between the three sites were 7534.4 lbs ac^{-1} with the highest yielding hybrid being Dyna-Gro's GX17962 at 8263.4 lbs ac^{-1} and the lowest yield being Dyna-Gro's M73GR55 at 6014 lbs ac^{-1}. Average yields were highest at KARE, followed by WREC, then Davis. KARE had significantly higher emergence and plant populations than WREC and Davis which may have impacted yield potential between the three sites. This is a switch from the previous two years when KARE had the lowest yields of the locations. Soil types may also have a relevant impact on yield potential, where the clay loam soils of WREC hold more water potential than the sandy loams of KARE and the loam of Davis.

Discussion

Overall, the emergence and yields were higher in 2018 than in 2017, with particular improvement from KARE. It is clear that grain sorghum can be an excellent cereal crop for California. The high yield potential and the marketability of the grain into various market channels would work well in conservation tillage practices within the state and as a rotation crop for other annual crops, such as cotton, canning tomatoes, or other vegetable crops.

Table 1. Various agronomic characteristics for grain sorghum hybrids grown in 3 locations in California in 2018, KARE, WREC, and the UC Davis Research Station.

Hybrid Information			Agronomic Measurements*			
Entry	**Company**	**Hybrid**	**Emerg[1]**	**Vigor[2]**	**Plant ac[3]**	**DTF[4]**
1	Dual Forage SCA	Dyna-Gro	67.06 d-e	4.58 a-d	51547 d-e	73.9 c
2	GX16921	Dyna-Gro	66.53 d-e	4.33 b-f	50980 d-e	75.3 b-c
3	GX17948	Dyna-Gro	75.33 a-c	4.17 d-f	57939 a-c	69.8 d-e
4	GX17962	Dyna-Gro	72.49 b-d	4.17 d-f	55388 b-d	60.2 g
5	GX16833	Dyna-Gro	69.31 c-e	4.50 a-e	53073 c-e	76.1 b
6	M73GR55	Dyna-Gro	70.77 c-e	4.00 f	53941 c-e	80 .0 a
7	M74GB17	Dyna-Gro	59.72 f	4.17 d-f	45790 f	71.6 d
8	M60GB31	Dyna-Gro	65.15 e-f	4.00 f	50109 e-f	63.1 f
9	GX17968	Dyna-Gro	70.83 b-e	4.17 d-f	54331 b-e	71.7 d
10	GX17379	Dyna-Gro	70.44 c-e	4.75 a-b	54229 b-e	70.9 d
11	M69GR88	Dyna-Gro	77.45 a-b	4.58 a-d	59282 a-b	73.9 c
12	DKS38-16	Monsanto	67.73 d-e	4.25 c-f	51920 d-e	57.9 h
13	DKS45-23	Monsanto	79.43 a	4.83 a	60974 a	68.0 e
14	DKS53-53	Monsanto	68.92 c-e	4.08 e-f	52800 d-e	71.1 d
15	DKS47-07	Monsanto	80.82 a	4.67 a-c	61973 a	64.4 f
Means **CV**			**70.80** **10.1**	**4.35** **8.22**	**54285.1** **10.04**	**69.8** **3.09**
Location						
KARE			**85.66 a**	**4.4 a**	**62688 a**	**68.3 b**
UC Davis			**69.27 b**	**4.3 a**	**50694 b**	**75.8 a**
WREC			**57.46 c**	**NA**	**49473 b**	**65.5 c**

*Means followed by the same letter do not significantly differ using LSD (P=0.05); [1]Emerge=Plant emergence based on stand count divided by seed planted; [2]Vigor based on rating from 1-5 with 1=very poor and 5=excellent; [3]plant ac=estimated plants per acre based on stand counts and plot area; [4]DTF=days to 50% flowering.

Table 2. Various agronomic and yield characteristics for grain sorghum hybrids grown in 3 locations in California in 2018, KARE, WREC, and the UC Davis Research Station.

Hybrid Information			Agronomic and Yield Measurements*				
Entry	**Company**	**Hybrid**	**Plant Height (cm)**	**Panicle Length (cm)**	**Exsertion (cm)**	**Yield lbs ac^{-1}**	**1000 seed weight (g)**
1	Dual Forage SCA	Dyna-Gro	136.3 a	23.4 d	0.4 f	8047.1 a	25.49 e-f
2	GX16921	Dyna-Gro	134.6 a-b	24.8 c-d	9.9a-b	7031.2 b	24.61 f-g
3	GX17948	Dyna-Gro	117.8 e	25.4 c-d	6.6 b-d	7396.5 a-b	28.29 b
4	GX17962	Dyna-Gro	108.3 f	26.7 b-c	7.6 b-c	8263.4 a	26.32 c-e
5	GX16833	Dyna-Gro	129.1 a-c	23.3 d	0.0 f	7695.0 a-b	23.58 g-h
6	M73GR55	Dyna-Gro	132.7 a-c	29.2 a-b	5.6 b-e	6014.0 c	23.17 h
7	M74GB17	Dyna-Gro	126.9 c-d	30.4 a	3.7 c-f	7773.3 a-b	26.81 c-e
8	M60GB31	Dyna-Gro	118.0 e	26.9 b-c	5.1 c-e	7993.3 a	23.92 g-h
9	GX17968	Dyna-Gro	118.0 e	25.4 c-d	12.8 a	7601.7 a-b	23.17 h
10	GX17379	Dyna-Gro	129.4 a-c	31.9 a	1.3 e-f	7454.6 a-b	30.96 a
11	M69GR88	Dyna-Gro	120.9 d-e	23.3 d	3.1 d-f	7699.2 a-b	25.93 d-f
12	DKS38-16	Monsanto	113.8 e-f	24.3 c-d	7.7 b-c	7966.2 a	23.57 g-h
13	DKS45-23	Monsanto	120.6 d-e	26.6 b-c	3.9 c-f	6935.6 b	27.10 b-d
14	DKS53-53	Monsanto	118.9 e	29.9 a	5.0 c-e	7010.1 b	27.41 b-c
15	DKS47-07	Monsanto	127.2 b-d	25.8 c-d	5.6 b-e	8147.8 a	26.79 c-e
Means			**123.50**	**26.50**	**5.2**	**7534.4**	**25.8**
CV			**6.4**	**10.87**	**88.80**	**12.73**	**5.74**
Location							
KARE			**123.27 b**	**23.2 b**	**3.7 b**	**8294.9 a**	**27.1 a**
UC Davis			**116.56 c**	**28.0 a**	**7.3 a**	**6234.1 c**	**24.2 c**
WREC			**130.67 a**	**28.4 a**	**4.6 b**	**8108.2 b**	**26.1 b**

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