UC-ANR
2017 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}. 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 stable 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 sorghum hybrid evaluation trials in 2016 and this report presents data from demonstration plots grown in four locations in 2017. These reports, along with help 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

Five seed companies provided 41 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 Desert Research and Extension Center (DREC), the Westside Research and Extension Center (WREC) and at the Russell Ranch Sustainable Agriculture Facility (DAVIS) at UC Davis. Fertility applications followed similar recommendation for grain sorghums for the region. The 2017 growing season was characterized by a break from the years-long drought that California has faced, which helped to restore some of the soil moisture reserves. Trials at KARE, DREC, 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 6, 2017
Planting Rate:	70,000 seed $acre^{-1}$
Seed Method:	Almaco 4 row plot planter
Fertilizer:	Planting 1: 1000 lbs ac^{-1} 21-7-14
Herbicide:	Dual Magnum at 1.3 pints per ac^{-1} as a pre-plant
Pesticide:	Sivanto 14 fl oz ac^{-1} for control of Sugarcane Aphid
Irrigation:	20.34 applied inches by furrow irrigation
Grain Harvest Date:	November 1, 2017 with an Almaco SPC 40 Plot Combine

Trial Location:	Westside Research and Extension Center, Five Points, CA
Cooperator:	UC-ANR Extension
Previous Crop:	Winter forage (wheat grown for silage-not taken to grain)
Soil Type:	Panoche clay loam
Plot Size:	Four, 30 inch rows by 20 ft
Replications:	3
Planting Date:	June 15, 2017
Planting Rate:	70,000 seed $acre^{-1}$
Seed Method:	Almaco 4 row plot planter
Fertilizer:	200 lbs $acre^{-1}$ N-P-K 11-52-00 on May 25 and 180 lbs $acre^{-1}$ N-P-K 46-00-00 urea on July 6
Herbicide:	Clarity 8oz on June 30 and Prowl-H_20 at 24 oz ac^{-1}
Pesticides:	Sivanto Prime 14oz ac^{-1} on August 11 and October 14

Irrigation:	Pre-plant irrigation of 8.2 inches on May 8, Sprinkler irrigation of 3.2 inches on June 6, 19, & 21 for stand establishment, gated pipe furrow irrigation subsequent irrigations for a total of 19.3 inches on July 11 & 31, Aug 28 and Sept. 7.
Grain Harvest Date:	November 2, 2017 with an Almaco SPC 40 Plot Combine

Trial Location:	UC Davis Research Station, Davis, CA
Cooperator:	UC-ANR
Previous Crop:	Small grains cover crop
Soil Type:	Reiff very fine sandy
Plot Size:	Four, 30 inch rows by 20 ft
Replications:	3
Planting Date:	May 26, 2017
Planting Rate:	70,000 seed $acre^{-1}$
Seed Method:	Wintersteiger Self Propelled Drill Planter
Fertilizer:	200 lbs ac^{-1} N in the form of urea.
Herbicide:	Dual Magnum as pre-plant
Irrigation:	
Grain Harvest Date:	Grain harvest did not take place because of machine issues

Trial Location:	Desert Research & Extension Center, Holtville, CA
Cooperator:	UCCE Imperial Valley, UC-ANR
Previous Crop:	Sudangrass
Soil Type:	Imperial-Glembar Salty Clay Loam
Plot Size:	Four, 30 inch rows by 20 ft
Replications:	3
Planting Date:	April 18, 2017
Planting Rate:	70,000 seed $acre^{-1}$
Seed Method:	
Fertilizer:	Pre-plant 11-52-00 at 400 lbs ac^{-1}
Herbicide:	Aatrex at 4 pints ac^{-1}
Irrigation:	
Grain Harvest Date:	Grain harvest did not take place because of sterility in all hybrids

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 the sites at 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). The grain yields at DREC were not harvested because the hybrids showed severe sterility or blasting within the seed panicles. DREC was planted in mid-April and flowered approximately 60 days after planting. Plantings in the Imperial Valley in mid-April may be too late for sorghum, in that temperatures at flowering in mid-June were averaging approximately 110º F. These temperatures, coupled with irrigations at flowering could have created conditions that may have sterilized the sorghum plants, thus resulting in very poor seed set and blasting of the ovaries. In the future, grain sorghum planting should be based around flowering date temperatures to avoid extreme temperatures at flowering. Harvesting of grain at Davis was not done because of issues with the grain harvester. Mechanical issues caused plots to not be harvested correctly and the data had to be discarded. Grain harvesting was normal at both WREC and KARE.

Early Agronomic Data
Emergence data ranged from a low of 49.81% in the hybrid 502/15 from Scott Seed to a high of 71.22 in the hybrid DKS51-01 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. Numbers were low at KARE compared to the other sites. KARE has a sandy loam soil type and its emergence patterns may be a reflection of these soils drying out much faster than the soils at WREC, DREC, and Davis causing undue early stress on emerging seedlings. Emergence can be a reflection of seed germination or quality, soil and moisture stress or other biotic stresses; however, these number should also reflect the estimated number of plants per acre. DREC, which had a high % emergence, similar to that of WREC had lower plant per acre than either WREC and Davis indicating that other issues may have impacted final stand counts at DREC. The final plant population would be considered modest population rates for irrigated sorghum and in the case of KARE on the low side (see Table 1; http://www.sorghumcheckoff.com/assets/media/productionguides/2011HighPlainsProductionHandbookFINAL.pdf and Mulkey et al., 1985). Flowering dates reflected the various maturities available in the grain sorghum hybrids being evaluated in the state. Flowering dates ranged from early, 48.8 days after planting with Sorghum Partners SP 31A15, to late flowering at 64.3 in the hybrid GW EXP 9050 from Gayland Ward Seed (Table 1). It has been reported in sorghum that late season sorghums tend to have better yield potential and this seems to be reflected in the data from this year's research, thought further statistical work and years will be needed to further validate this. All the early agronomic data indicated that location did have a significant impact on data collected from these sites.

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. DREC was significantly different in all the height measurements which could have been a reflection of the heat stress that occurred during vegetative growth stages of sorghum in the Imperial Valley. Plant heights ranged from 100.6 cm (Sorghum Partners' SP 31A15) to a high of 152.6 cm (Dyna-Gro Seed GX13692 (X)). Average yields between KARE and WREC were 5620.3 lbs ac-1 with the highest yield hybrid being Gayland Ward Seed's GW EXP 9050 at 6861.6 lbs ac^{-1} with the lowest yield being Sorghum Partners SP 73B12 at 4251.7 lbs ac^{-1}. Average yields were greater at WREC than at KARE. KARE had significantly lower emergence and plant populations than WREC which may have impacted yield potential between the two sites. In addition, WREC has shown greater yield potential for grain sorghum in the previous grain hybrid evaluation in 2016. 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.

Discussion

In 2016, it was reported that maturities for the sorghum hybrids are not reliable in California and therefore should not be used for the purposes of experimental blocking. The highest yielding hybrids tended to be mid-late flowering hybrids and this was similar to trends from this year. 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 crop 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 4 locations in California in 2017, Desert Research & Extension Center in Imperial Valley, the Kearney Agricultural Research & Extension Center and the Westside Research & Extension Center in Fresno County, and the Russell Ranch Sustainable Agriculture Facility at UC Davis.

Hybrid Information			Agronomic Measurements*			
Entry	**Company**	**Hybrid**	**Emerg**[1]	**Vigor**[2]	**plant ac**[3]	**DTF**[4]
1	Chomatin Inc.	CHR0029	63.37 a-g	3.83	43026 b-k	59.0 h-n
2	Chomatin Inc.	CHR2042	65.69 a-d	4.06	44351 a-f	57.3 mn
3	Dyna-Gro Seed	Dual Forage SCA	58.77 d-i	4.00	39415 f-l	61.1 c-i
4	Dyna-Gro Seed	M74GB17	60.71 b-g	3.78	41246 c-k	59.5 f-m
5	Dyna-Gro Seed	765B	54.62 f-i	3.50	36926 j-l	58.8 h-n
6	Dyna-Gro Seed	GX16833 (X)	64.37 a-e	3.72	43552 b-g	61.2 c-h
7	Dyna-Gro Seed	GX17818 (X)	54.54 g-i	3.44	37415 h-l	59.9 e-l
8	Dyna-Gro Seed	GX13692 (X)	61.43 b-g	4.06	41773 c-k	61.8 c-f
9	Monsanto	DKS38-16	62.59 a-g	4.00	42499 b-k	50.1 q
10	Monsanto	DKS45-23	68.96 a-c	4.06	47182 a-c	58.3 j-n
11	Monsanto	DKS51-01	71.22 a	4.28	48345 ab	54.0 o
12	Monsanto	DKS53-53	62.67 a-g	3.83	42934 b-k	59.4 g-n
13	Scott Seed Co.	503/15	64.37 a-e	4.22	43824 b-g	60.8 c-i
14	Scott Seed Co.	504/06	64.35 a-e	4.22	43172 b-k	61.9 c-e
15	Scott Seed Co.	504/15	69.46 ab	3.83	46857 a-c	62.4 b-d
16	Scott Seed Co.	505/5	63.33 a-g	3.89	43279 b-i	48.9 q
17	Scott Seed Co.	543/46	61.80 b-g	4.17	41719 c-k	59.8 e-l
18	Scott Seed Co.	545/15	55.62 e-i	3.33	37996 g-l	57.1 n
19	Scott Seed Co.	502/15	49.81 i	3.33	33984 l	61.0 c-i
20	Scott Seed Co.	506/32	54.19 g-i	3.94	37106 i-l	59.8 e-l

Table 1. Continued

Hybrid Information			Agronomic Measurements			
Entry	**Company**	**Hybrid**	**% Emerg**[1]	**Vigor**[2]	**plant ac**[3]	**DTF**[4]
21	Scott Seed Co.	506/15	60.28 b-g	4.33	41101 c-k	59.9 e-l
22	Sorghum Partners	SP 70B17	67.72 a-d	3.96	46531 a-d	52.7 op
23	Sorghum Partners	SP 73B12	60.19 b-g	3.94	41245 c-k	59.0 h-n
24	Sorghum Partners	SP 68M57	67.68 a-d	4.17	46002 a-d	49.3 q
25	Sorghum Partners	SP 31A15	60.65 b-g	3.83	41644 c-k	48.8 q
26	Sorghum Partners	SP 34A19	65.57 a-d	4.06	44514 a-f	51.1 pq
27	Sorghum Partners	SP 78M30	62.88 a-g	3.78	42898 b-k	61.1 c-i
28	Gayland Ward Seed	GW EXP 9092	61.44 b-g	3.94	44576 a-f	58.0 k-n
29	Gayland Ward Seed	GW 15G901	60.00 c-h	3.83	39640 e-l	63.1 bc
30	Gayland Ward Seed	GW 15G926	64.11 a-e	4.06	46803 a-c	61.8 c-f
31	Gayland Ward Seed	GW EXP 9066	61.56 b-g	4.44	45012 a-f	60.6 d-j
32	Gayland Ward Seed	GW EXP 9100	66.22 a-d	4.28	44915 a-f	66.2 a
33	Gayland Ward Seed	GW EXP 9050	66.22 a-d	3.94	48497 ab	64.3 ab
34	Gayland Ward Seed	GW EXP 8016	50.22 i	3.61	36881 kl	60.2 d-k
35	Gayland Ward Seed	GW 1160	63.89 a-f	4.06	46754 a-c	58.0 k-n
36	Gayland Ward Seed	GW EXP 9134	55.11 e-i	3.44	40220 d-l	61.6 c-g
37	Gayland Ward Seed	GW EXP 9138	59.11 d-i	3.72	43221 b-j	58.4 j-n
38	Gayland Ward Seed	GW EXP 9139	50.78 hi	4.00	37171 i-l	57.7 l-n
39	Gayland Ward Seed	GW EXP 9135	68.67 a-c	3.89	50384 a	59.6 f-m

Table 1. Continued

Hybrid Information			Agronomic Measurements			
Entry	**Company**	**Hybrid**	**% Emerg**[1]	**Vigor**[2]	**plant ac**[3]	**DTF**[4]
40	Gayland Ward Seed	GW EXP 9127	62.78 a-g	4.28	45835 a-e	59.2 g-n
41	Gayland Ward Seed	GW EXP 9092	64.33 a-e	4.06	47045 a-c	58.8 i-n
Means			**61.84**	**3.93**	**42778.4**	**58.4**
CV			**17.8**	**15.32**	**17.43**	**4.72**
Location						
DREC			**70.46 a**		**38710 c**	**37.0 d**
KARE			**46.25 c**	**4.03 b**	**33701 d**	**64.0 b**
WREC			**71.98 a**	**3.25 c**	**52442 a**	**59.7 c**
DAVIS			**61.64 b**	**4.49 a**	**44822 b**	**65.3 a**

*Means followed by the same letter do not significantly differ using LSD (P=0.05); [1]Emerg = 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 4 locations in California in 2017, Desert Research & Extension Center in Imperial Valley, the Kearney Agricultural Research & Extension Center and the Westside Research & Extension Center in Fresno County, and the Russell Ranch Sustainable Agriculture Facility at UC Davis.

Hybrid Information			**Agronomic and Yield Measurements***				
Entry	**Company**	**Hybrid**	**Plant Ht (cm)**	**Panicle Lgh (cm)**	**Exsertion (cm)**	**Yield[5] lbs ac^{-1}**	**1000 seed[6] weight (g)**
1	Chomatin Inc.	CHR0029	128.2 i-l	29.0 a-f	1.8 l-o	4261.8 k	28.50 ab
2	Chomatin Inc.	CHR2042	126.2 j-n	26.3 f-m	7.2 d-i	6196.6 a-e	26.27 c-f
3	Dyna-Gro Seed	Dual Forage SCA	135.1 d-h	20.5 t	5.1 e-n	6703.6 ab	24.31 f-l
4	Dyna-Gro Seed	M74GB17	122.6 l-o	27.7 c-h	5.1 e-n	6045.9 a-e	24.78 d-j
5	Dyna-Gro Seed	765B	130.6 g-k	24.6 i-q	5.6 d-n	5097.4 e-k	23.37 j-p
6	Dyna-Gro Seed	GX16833 (X)	128.7 h-l	21.9 p-t	2.3 k-o	6774.5 ab	23.65 h-o
7	Dyna-Gro Seed	GX17818 (X)	120.8 m-p	23.9 k-s	9.4 c-e	5507.9 c-j	21.04 r
8	Dyna-Gro Seed	GX13692 (X)	152.6 a	22.0 p-t	7.4 d-i	5719.3 a-i	29.61 a
9	Monsanto	DKS38-16	115.6 p-r	23.5 m-s	8.1 d-h	6048.4 a-e	21.41 p-r
10	Monsanto	DKS45-23	128.1 i-l	25.8 g-n	4.5 h-o	6111.7 a-e	25.59 c-h
11	Monsanto	DKS51-01	126.7 i-m	25.7 g-n	9.3 c-f	5296.6 c-k	17.82 s
12	Monsanto	DKS53-53	122.9 l-o	25.4 h-o	2.7 k-o	5906.9 a-g	26.69 b-d
13	Scott Seed Co.	503/15	138.5 b-f	21.8 q-t	2.5 k-o	6389.9 a-d	23.78 h-n
14	Scott Seed Co.	504/06	122.4 l-p	21.6 r-t	1.5 no	4793.4 g-k	25.42 d-i
15	Scott Seed Co.	504/15	130.3 g-k	21.1 st	3.7 i-o	6321.2 a-d	23.29 j-q
16	Scott Seed Co.	505/5	108.1 s	27.5 c-h	10.0 cd	4615.4 i-k	24.43 e-l
17	Scott Seed Co.	543/46	123.1 l-o	23.8 k-s	2.6 k-o	4826.7 f-k	27.43 bc
18	Scott Seed Co.	545/15	116.7 o-q	24.6 i-p	4.8 g-o	5683.6 b-i	22.21 m-r
19	Scott Seed Co.	502/15	119.6 n-p	23.7 l-s	1.6 m-o	5945.5 a-g	24.13 g-m
20	Scott Seed Co.	506/32	122.7 l-o	25.4 h-o	0.4 o	4720.5 h-k	25.91 c-g
21	Scott Seed Co.	506/15	137.7 b-f	22.8 o-t	2.6 k-o	6367.0 a-d	22.52 l-r
22	Sorghum Partners	SP 70B17	125.4 k-n	29.4 a-d	6.0 d-l	5749.8 a-i	25.22 d-j

Table 2: Continued.

Hybrid Information			Agronomic and Yield Measurements*				
Entry	**Company**	**Hybrid**	**Plant Ht (cm)**	**Panicle Lgh (cm)**	**Exsertion (cm)**	**Yield[5] lbs ac^{-1}**	**1000 seed[6] weight (g)**
23	Sorghum Partners	SP 73B12	117.0 o-q	26.4 f-l	3.5 i-o	4251.7 k	27.49 bc
24	Sorghum Partners	SP 68M57	109.3 rs	26.8 d-j	3.6 i-o	5470.0 c-j	23.56 i-o
25	Sorghum Partners	SP 31A15	100.6 t	24.2 j-r	7.5 d-i	5289.5 d-k	21.16 r
26	Sorghum Partners	SP 34A19	112.2 q-s	25.8 g-n	7.0 d-j	5293.9 c-k	21.67 o-r
27	Sorghum Partners	SP 78M30	125.6 k-n	29.7 a-c	2.8 j-o	5621.5 b-i	24.79 d-j
28	Gayland Ward Seed	GW EXP 9092	133.1 e-i	27.2 c-i	7.2 d-i	5404.3 c-k	21.91 n-r
29	Gayland Ward Seed	GW 15G901	136.4 c-g	21.6 r-t	6.4 d-k	4379.5 jk	24.74 d-k
30	Gayland Ward Seed	GW 15G926	140.3 b-d	28.3 b-g	5.0 f-n	5083.3 e-k	21.16 r
31	Gayland Ward Seed	GW EXP 9066	135.9 c-g	27.9 c-h	16.4 ab	5935.8 a-g	21.31 qr
32	Gayland Ward Seed	GW EXP 9100	143.9	23.3 n-t	3.8 h-o	6448.2 a-c	26.41 c-e
33	Gayland Ward Seed	GW EXP 9050	139.6 b-e	29.3 a-e	4.0 h-o	6861.6 a	22.74 k-r
34	Gayland Ward Seed	GW EXP 8016	131.8 f-k	30.9 ab	5.9 d-m	6322.8 a-d	21.11 r
35	Gayland Ward Seed	GW 1160	128.3 h-l	28.7 b-f	12.9 bc	5468.4 c-j	22.68 l-r
36	Gayland Ward Seed	GW EXP 9134	143.4 b	26.6 e-k	9.0 c-g	5871.7 a-h	23.55 i-o
37	Gayland Ward Seed	GW EXP 9138	142.6 bc	27.3 c-i	18.8 a	5087.6 e-k	25.12 d-j
38	Gayland Ward Seed	GW EXP 9139	122.8 l-o	28.4 b-g	15.9 ab	4735.7 h-k	21.10 r
39	Gayland Ward Seed	GW EXP 9135	132.4 f-j	27.1 c-i	9.2 c-f	5953.1 a-f	18.29 s

Table 2: Continued.

Hybrid Information			Agronomic and Yield Measurements*				
Entry	**Company**	**Hybrid**	**Plant Ht (cm)**	**Panicle Lgh (cm)**	**Exsertion (cm)**	**Yield[5] lbs ac^{-1}**	**1000 seed[6] weight (g)**
40	Gayland Ward Seed	GW EXP 9127	138.4 b-f	25.1 h-o	9.7 cd	5976.5 a-f	25.38 d-i
41	Gayland Ward Seed	GW EXP 9092	132.4 f-j	31.8 a	9.2 c-f	5894.6 a-g	25.25 d-j
Means			**127.3**	**25.6**	**5.2**	**5620.3**	**23.80**
CV			**6.32**	**12.99**	**84.57**	**17.94**	**7.29**
Location							
DREC			**102.3 d**	**22.3 c**	**3.9 b**		
KARE			**116.8 c**	**21.4 c**	**4.5 b**	**4607.3 b**	**24.89 a**
WREC			**139.1 b**	**28.1 b**	**7.0 a**	**6633.4 a**	**22.72 b**
DAVIS			**142.0 a**	**29.3 a**	**8.3 a**		

*Means followed by the same letter do not significantly differ using LSD (P=0.05); [5]Yield means are from 3 locations as there were no yield data points from the Desert Research & Extension Center; [6]1000 seed weights were only available from samples from Kearney and Westside research sites.