Final Report
UC-ANR
2017 Field Research on Sorghum Forages for the California Dairy Industry

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Introduction
The San Joaquin Valley of California is home to a multi-billion dollar dairy industry. Continuing winter droughts and poor water allocations have spurred renewed interest in forage sorghums as an option in silage pits within the dairy industry; sorghum is known for its inherent drought tolerance. It was estimated that between 70-90,000 acres of forage sorghum were planted in the state in 2016. This was the seventh year of sorghum forage and sudangrass trials planted at the Kearney Agricultural Research and Extension (KARE) Center and the Westside Research and Extension (WREC) Center to evaluate commercially available sorghum forages. This was the second year with a second planting at KARE and a site planted at the UC Davis Research Farm (UC Davis). Sugarcane Aphid (SCA) was again a problem pest after appearing in California for the first-time last year. Each of the San Joaquin Valley sites sprayed insecticides to keep it under control, but the WREC plots were too badly infested to make harvest feasible. UC ANR research in the San Joaquin Valley continues on control methods for this pest.

Methods and Materials
Six seed companies provided a total of 44 hybrids, which included traditional forage sorghums, Photoperiod sensitive (PS) forage sorghums, and brown mid-rib (BMR) derivatives of both traditional and PS sorghums. Hybrids were planted in a randomized block design in four row plots planted on 30-inch raised beds and were analyzed as a split-plot design, with the main plot being location and the sub-plot being variety. Irrigation was applied using furrow irrigation at Kearney and a combination of overhead sprinklers and flood irrigation at the Westside Center and at the Davis Farm. Fertility applications followed similar recommendation for forage sorghums for the region. The 2017 growing season was characterized by a break from the year-long drought that California has faced, which helped to restore some of the soil moisture reserves. Trials at Kearney, Westside and Davis were irrigated as needed and according to ET demands of the crop at the various locations. The first planting at KARE received a preplant irrigation of 5.3 inches on May 2, 2017 and a total of 18.61 inches of applied irrigation. The second planting at KARE received a preplant irrigation of 6.19 inches on May 24, 2017 and a total of 18.04 inches of applied irrigation. Rainfall totals from January through May 12, 2017

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prior to the first planting at KARE were 9.51 inches, while the second planting had a total of 9.52 inches of rain prior to planting. Rainfall totals of 0.01 and 0.14 inches were recorded throughout the growing season for the two planting dates, respectively.

Rainfall totals from January through June prior to planting at WREC were 6.1 inches, while no rainfall was recorded throughout the growing season. At WREC, there was a pre-plant irrigation of 8.2 inches on May 8 and then a total of 3.2 inches was delivered between June 16 and June 21 using sprinklers to ensure good stand establishment. An additional 19.3 was applied by furrow irrigation over the course of the season. In total, 30.7 inches of irrigation were applied in the 2017 season. Rainfall totals from January through May 26 prior to planting at UC Davis were 23.87 inches, while 0.76 inches fell throughout the growing season. The trial was irrigated to field capacity every two weeks from May 31st to August 16th. Trials were harvested approximately 100 days after planting.

Other cultural practices and study information are listed below:

- **Trial Location:** KARE Planting 1 and 2, Parlier
- **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:** May 12 and June 6, 2017
- **Planting Rate:** 100,000 seed acre\(^{-1}\)
- **Seed Method:** Almaco 4 row plot planter
- **Fertilizer:** Planting 1: 500 lbs ac\(^{-1}\) 21-7-14, Planting 2: 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\(^{-1}\) on both plantings on July 25 and on Planting 2 on August 9
- **Irrigation:** See narrative above
- **Silage Harvest Date:** Plots harvested with Wintersteiger Cibus S forage chopper on August 22 and September 14, 2017
<table>
<thead>
<tr>
<th>Trial Location:</th>
<th>Westside Research and Extension Center, Five Points</th>
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<tr>
<td>Cooperator:</td>
<td>UC-ANR Extension</td>
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<tr>
<td>Previous Crop:</td>
<td>Winter forage (wheat grown for silage-not taken to grain)</td>
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<tr>
<td>Soil Type:</td>
<td>Panoche clay loam</td>
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<tr>
<td>Plot Size:</td>
<td>Four, 30 inch rows by 20 ft</td>
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<td>Replications:</td>
<td>3</td>
</tr>
<tr>
<td>Planting Date:</td>
<td>June 15, 2017</td>
</tr>
<tr>
<td>Planting Rate:</td>
<td>100,000 seed acre⁻¹</td>
</tr>
<tr>
<td>Seed Method:</td>
<td>Almaco 4 row plot planter</td>
</tr>
<tr>
<td>Fertilizer:</td>
<td>200 lbs acre⁻¹ N-P-K 11-52-00 on May 25 and 80 lbs acre⁻¹ N-P-K 46-00-00 urea on July 6</td>
</tr>
<tr>
<td>Herbicide:</td>
<td>Clarity 8oz on June 30 and Prowl-H₂O at 24 oz ac⁻¹ on July 11</td>
</tr>
<tr>
<td>Pesticides:</td>
<td>Sivanto Prime 14oz ac⁻¹ on August 11 and October 14</td>
</tr>
<tr>
<td>Irrigation:</td>
<td>Sprinklers for pre-irrigation and stand establishment, gated pipe furrow irrigation subsequent irrigations – see narrative for amounts</td>
</tr>
<tr>
<td>Silage Harvest Date:</td>
<td>A heavy Sugar Cane Aphid (SCA) infestation made harvesting impossible.</td>
</tr>
<tr>
<td>Data Collected:</td>
<td></td>
</tr>
<tr>
<td>1. Plant stands</td>
<td></td>
</tr>
<tr>
<td>2. Plant height (cm) at silage harvest</td>
<td></td>
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<tr>
<td>3. Lodging at silage harvest. Percent of fallen or significantly leaning plants per plot.</td>
<td></td>
</tr>
<tr>
<td>4. Moisture Content at Harvest.</td>
<td></td>
</tr>
<tr>
<td>5. Forage (silage) yield. The middle two rows of each plot were harvested with a Wintersteiger Cibus S forage chopper. Yields are reported at 65% moisture in tons/acre.</td>
<td></td>
</tr>
<tr>
<td>6. Nutrient analysis: Samples were collected from the forage chopper in the field, weighed and then placed in forced air Gruenberg oven (Model T35HV216, Williamsport, PA) at</td>
<td></td>
</tr>
</tbody>
</table>
50º C until dried. These sub-samples were sent to Dairyland Laboratory, Inc, Arcadia, WI for analysis.

7. Key Nutrient Analysis Definitions
   a. Crude Protein: 6.25 times % total nitrogen
   b. ADF: % Acid Detergent Fiber; constituent of the cell wall includes cellulose and lignin; inversely related to energy availability
   c. NDF: Neutral Detergent Fiber; cell wall fraction of the forage
   d. Lignin: percent estimated lignin present
   e. Starch: estimated starch content
   f. Fat: estimated fat content
   g. NDFd30: neutral detergent fiber digestibility over 30 hours
   h. NDFd240: neutral detergent fiber digestibility over 240 hours
   i. RFV: Relative Feed Value is an index for comparing forages based on digestibility and intake potential. RFV is calculated from ADF and NDF. An RFV of 100 is considered the average score and represents alfalfa hay containing 41% ADF and 53% NDF on a dry matter digestibility.
   j. RFQ: Relative Feed Quality is an index for comparing forages calculated from TDN and DMI. An RFQ of 100 is considered the average score and represents fully mature alfalfa.
   k. Milk lbs/ton: A projection of potential milk yield per ton for forage dry matter.

Data was analyzed using the SAS statistical package.
Results
A summary of yield, agronomic traits and nutritional analyses are reported by types of forage
sorghums grown in the all locations in Table 1. See Tables 2 and 3 for a comparison of the
different hybrids’ agronomic, yield, and nutritional characteristics.

Table 1. Summary of key forage characteristics by type of forage grown at three locations,
Kearney (2 planting dates), and Davis in 2017.

<table>
<thead>
<tr>
<th>Sorghum Type</th>
<th>% Lodging @ Harvest</th>
<th>Tons/ac @65% Moist.</th>
<th>% Crude Protein</th>
<th>% ADF</th>
<th>% NDF</th>
<th>% Lignin</th>
<th>% NDF D30</th>
<th>% NDF D240</th>
<th>Milk lbs/ton DM</th>
<th>Relative Feed Quality (RFQ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMR (24)</td>
<td>21.37 a</td>
<td>17.57 c</td>
<td>9.54 c</td>
<td>39.5 c</td>
<td>59.9 c</td>
<td>5.34 b</td>
<td>52.9 a</td>
<td>72.11 b</td>
<td>2351.8 a</td>
<td>95.18 a</td>
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<tr>
<td>NonBMR (15)</td>
<td>18.21 a</td>
<td>20.23 b</td>
<td>8.41 b</td>
<td>38.4 c</td>
<td>57.8 c</td>
<td>5.88 a</td>
<td>46.7 b</td>
<td>65.36 c</td>
<td>2434.2 a</td>
<td>91.62 ab</td>
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<tr>
<td>PSBMR (3)</td>
<td>22.50 a</td>
<td>15.99 c</td>
<td>10.14 a</td>
<td>43.6 b</td>
<td>65.2 b</td>
<td>5.27 b</td>
<td>55.7 a</td>
<td>78.36 a</td>
<td>2034.6 b</td>
<td>84.06 b</td>
</tr>
<tr>
<td>PSNonBMR (2)</td>
<td>8.61 a</td>
<td>23.86 a</td>
<td>7.27 c</td>
<td>46.3 a</td>
<td>69.4 a</td>
<td>6.27 a</td>
<td>45.2 b</td>
<td>69.09 b</td>
<td>1792.8 c</td>
<td>59.94 c</td>
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<tr>
<td>Trial Avg.</td>
<td>19.74</td>
<td>18.69</td>
<td>9.07</td>
<td>39.68 a</td>
<td>59.95</td>
<td>5.57</td>
<td>50.50</td>
<td>69.97</td>
<td>2336.6</td>
<td>91.64</td>
</tr>
</tbody>
</table>

1Number in parenthesis is the number of hybrids in each sorghum type. BMR = brown midrib; PS = Photoperiod
sensitive.
2Means followed by the same letter do not significantly differ using LSD (P=0.05)

Lodging was significantly different among all four sites, with the lowest lodging % occurring at
the first planting of the KARE trial and the highest at WREC. The first planting at KARE took
place the first week of May and this may be the optimum time to plant forage sorghums to
reduce lodging issues that can happen under ideal, hot growing conditions here in the valley. UC
Davis produced significantly higher forage yields than either planting at KARE.

Forage yields for the trials ranged from a high of 28.6 to 12.7 tons acre\(^{-1}\) with an average of 18.7
tons acre\(^{-1}\) (see Tables 1 and 2). The non-BMR PS forages were slightly more productive than
their BMR counterparts, similar to findings from previous years (Table 1). Planting at Davis
consistently yielded significantly higher tons acre\(^{-1}\) in production, while the earlier planting at
Kearney saw significantly less lodging than the other sites (Table 2). The increased yields at
Davis could be attributed to greater soil moisture during the winter and less water stress over the
growing season.

Similar to previous reports, lodging can be a major issue for forage sorghums. Lodging ranged
from 0.4 to 80.5% (Table 2). There were no significant differences in lodging among any of the
forage types this year.

Digestibility as measured by ADF, NDF, 30 and 240 hours NDFd, and overall forage quality as
predicted by lbs of milk per dry ton and relative forage quality was significantly highest in the
BMR sorghums (Table 1), though there were some excellent non-BMR forages as well (Table 3).
Photoperiod sensitive forage sorghum, though high yielding, were relatively poor nutritionally.
Nutritional information is important for establishing the baseline nutrition of the silage and is key
to understanding the proper formulation of the feed for adequate nutrition for the dairy animal.
The top 10 hybrids were ranked in this study by taking those hybrids with the greatest yields and eliminating those hybrids that lodged by more than 10% (Table 4). Of these hybrids, yield ranged from a low of 17.1 tons acre\(^{-1}\) with Richardson RS1 to a high of 24.8 tons acre\(^{-1}\) with Scott Seed 54243X.

For many producers, yield is the greatest factor in their selection of sorghum forages. Table 5 highlights the top yielding hybrids that produced more than 20.0 tons acre\(^{-1}\) of yield. The highest yielding forage sorghum was SP 1615 from Chromatin/Sorghum Partners, LLC at 28.6 tons acre\(^{-1}\) followed by Chromatin/Sorghum Partners SS405 at 26.2 tons acre\(^{-1}\). As in past years, lodging was associated with some of the highest yielding forage sorghums.

**Discussion**

This was the seventh year that a wide range of forage sorghums (44), both commercial and experimental, were evaluated for both yield and quality parameters in large replicated trials in three locations in California. Although the sites received more rainfall in 2017 than in recent years, particularly at UC Davis, it continues to be important to maximize irrigation and fertilizer efficiency. Given the limited amount of irrigation used in these studies, low inputs and high yields, the potential does exist in sorghum forages to save both water and fertilizer, both costly inputs in the production of forages in the state. Forage selection should be a combination of factors that optimize quality, yield and standability (lodging resistance) and will require additional management of feed rations to optimize the potential of these forage crops to supplement the feeding needs of dairies in the state.
Table 2. 2017 comparisons of sorghum forage hybrids and locations for agronomic characteristics and yield at KARE, WREC, and UC Davis by seed company.

<table>
<thead>
<tr>
<th>Hybrid Information¹</th>
<th>Agronomic Measurements²</th>
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<tbody>
<tr>
<td>Hybrid</td>
<td>Company</td>
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<tr>
<td>AF7401</td>
<td>Alta Seeds</td>
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<tr>
<td>XF7302</td>
<td>Alta Seeds</td>
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<td>Alta Seeds</td>
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<tr>
<td>XF7103</td>
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<tr>
<td>705F</td>
<td>Dyna-Gro Seed</td>
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<tr>
<td>F74FS23 BMR</td>
<td>Dyna-Gro Seed</td>
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<tr>
<td>F73FS10</td>
<td>Dyna-Gro Seed</td>
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<tr>
<td>F76FS77 BMR</td>
<td>Dyna-Gro Seed</td>
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<td>Fullgraze BMR</td>
<td>Dyna-Gro Seed</td>
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<td>Danny Boy BMR</td>
<td>Dyna-Gro Seed</td>
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<tr>
<td>Dual Forage SCA</td>
<td>Dyna-Gro Seed</td>
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<tr>
<td>GW 400 BMR</td>
<td>Gayland Ward Seed</td>
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<td>GW 475 BMR</td>
<td>Gayland Ward Seed</td>
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<tr>
<td>GW 600 BMR</td>
<td>Gayland Ward Seed</td>
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<tr>
<td>Silo Pro BMR</td>
<td>Gayland Ward Seed</td>
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<td>GW EXP 15F1097</td>
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<td>GW EXP 15F909</td>
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<td>GW EXP 15F910</td>
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<tr>
<td>Super Sugar DM</td>
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<td>Sweet Forever BMR</td>
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<td>Nutra King BMR</td>
<td>Gayland Ward Seed</td>
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<tr>
<td>Sweet Six BMR</td>
<td>Gayland Ward Seed</td>
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<td>RX1</td>
<td>Richardson Seeds</td>
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Table 2. continued.

<table>
<thead>
<tr>
<th>Hybrid</th>
<th>Company</th>
<th>Type</th>
<th>Maturity</th>
<th>BMR</th>
<th>% Lodging</th>
<th>Height (cm)</th>
<th>Ton ac-1 65% Moist</th>
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<tbody>
<tr>
<td>RX2</td>
<td>Richardson Seeds</td>
<td>F</td>
<td>E</td>
<td>N</td>
<td>7.9 p-s</td>
<td>148.8 o-q</td>
<td>18.4 f-o</td>
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<tr>
<td>SPX56216 BD</td>
<td>Sorghum Partners</td>
<td>F</td>
<td>ML</td>
<td>Y</td>
<td>48.3 c-h</td>
<td>227.3 k-l</td>
<td>16.4 k-s</td>
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<tr>
<td>NK300</td>
<td>Sorghum Partners</td>
<td>F</td>
<td>E</td>
<td>N</td>
<td>3.8 q-s</td>
<td>163.0 n-p</td>
<td>22.2 c-f</td>
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<tr>
<td>SS405</td>
<td>Sorghum Partners</td>
<td>F</td>
<td>L</td>
<td>N</td>
<td>51.0 c-f</td>
<td>293.7 b</td>
<td>26.2 a-b</td>
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<tr>
<td>SP1615</td>
<td>Sorghum Partners</td>
<td>F</td>
<td>PS</td>
<td>N</td>
<td>31.7 h-m</td>
<td>288.9 b-c</td>
<td>28.6 a</td>
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<td>SP2774</td>
<td>Sorghum Partners</td>
<td>F</td>
<td>M</td>
<td>Y</td>
<td>22.9 k-p</td>
<td>276.2 b-f</td>
<td>21.9 c-g</td>
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<td>SP2876</td>
<td>Sorghum Partners</td>
<td>F</td>
<td>M</td>
<td>Y</td>
<td>30.3 i-n</td>
<td>255.4 f-j</td>
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<tr>
<td>SP3903 BD</td>
<td>Sorghum Partners</td>
<td>F</td>
<td>ML</td>
<td>Y</td>
<td>6.3 p-s</td>
<td>158.5 n-p</td>
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<tr>
<td>SP4555</td>
<td>Sorghum Partners</td>
<td>F</td>
<td>M</td>
<td>Y</td>
<td>72.9 a-b</td>
<td>245.6 i-l</td>
<td>15.1 n-s</td>
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<td>SP1880</td>
<td>Sorghum Partners</td>
<td>F</td>
<td>L</td>
<td>N</td>
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<td>318.8 a</td>
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<td>506/10</td>
<td>Scott Seed Co.</td>
<td>F</td>
<td>L</td>
<td>Y</td>
<td>0.8 r-s</td>
<td>147.9 p-q</td>
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<td>514/10</td>
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<td>L</td>
<td>Y</td>
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<td>170.1 m-o</td>
<td>17.0 i-r</td>
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<td>512/09</td>
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<td>PS</td>
<td>N</td>
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<td>M</td>
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<td>13.3 n-s</td>
<td>124.0 r-s</td>
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<td>50644X</td>
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<td>PS</td>
<td>Y</td>
<td>23.3 j-p</td>
<td>188.9 m</td>
<td>12.7 s</td>
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<td>54243X</td>
<td>Scott Seed Co.</td>
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<td>L</td>
<td>Y</td>
<td>9.6 o-s</td>
<td>275.3 b-g</td>
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<td><strong>Means</strong></td>
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<td>22.3</td>
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**Location**

<table>
<thead>
<tr>
<th>Location</th>
<th>Mean</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>KARE1</td>
<td>10.0 d</td>
<td>167.5 d</td>
</tr>
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<td>KARE2</td>
<td>28.5 b</td>
<td>194.4 c</td>
</tr>
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Hybrid information provided by seed companies. F=Forage sorghum, E=Early, ME=Medium Early, M=Medium, ML=Medium Late, L=Late, PS=Photoperiod Sensitive.

Means followed by the same letter do not significantly differ using LSD (P=0.05)
Table 3. 2017 comparisons of sorghum forage hybrids and locations for nutrient composition and calculations at KARE, WREC, and UC Davis by seed company.

<table>
<thead>
<tr>
<th>Hybrid</th>
<th>Company</th>
<th>Type</th>
<th>Maturity</th>
<th>BMR</th>
<th>% Crude Protein</th>
<th>% ADF</th>
<th>% NDF</th>
<th>% Lignin</th>
<th>% Starch</th>
<th>% Fat</th>
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<td>L</td>
<td>Y</td>
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<td>40.2 e-j</td>
<td>60.5 e-h</td>
<td>5.13 i-n</td>
<td>6.6 g-m</td>
<td>2.2 a-e</td>
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<td>M</td>
<td>Y</td>
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<td>M</td>
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<td>E</td>
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<td>Y</td>
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<td>N</td>
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<th>Nutrient Composition &amp; Calculations²</th>
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<th>Type</th>
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<th>BMR</th>
<th>% Crude Protein</th>
<th>% ADF</th>
<th>% NDF</th>
<th>% Lignin</th>
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<td>ME</td>
<td>Y</td>
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<td>96.01 f-m</td>
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<td>M</td>
<td>N</td>
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<td>2256.6 f-m</td>
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<td>F</td>
<td>L</td>
<td>N</td>
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<td>0.129 f-m</td>
<td>2104.4 j-n</td>
<td>81.45 l-o</td>
<td>71.65 q-s</td>
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<td>L</td>
<td>Y</td>
<td>1.85 l-p</td>
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<td>Y</td>
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<td>104.56 c-e</td>
<td>103.69 c-h</td>
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<td>ME</td>
<td>Y</td>
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<td>104.02 c-e</td>
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<td>Type</td>
<td>Maturity</td>
<td>BMR</td>
<td>% K</td>
<td>% S</td>
<td>Milk Lbs ton-1</td>
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<td>Rel. Forage Quality</td>
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<td>E</td>
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<td>E</td>
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<td>E</td>
<td>N</td>
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<td>L</td>
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<td>0.101 o-q</td>
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<td>87.76 i-n</td>
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<td>Y</td>
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<td>65.93 s-u</td>
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<td>ML</td>
<td>N</td>
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<td>1966.8 m-o</td>
<td>78.39 n-o</td>
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<td>L</td>
<td>Y</td>
<td>1.73 p-u</td>
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<td>0.143 c-i</td>
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<td>Company</td>
<td>Type</td>
<td>Maturity</td>
<td>BMR</td>
<td>% K</td>
<td>% S</td>
<td>Milk Lbs ton-1</td>
<td>Rel. Feed Value</td>
<td>Rel. Forage Quality</td>
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<td>3.38 a</td>
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<td>1959.1 n-o</td>
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1Hybrid information provided by seed companies. F=Forage sorghum, E=Early, ME=Medium Early, M=Medium, ML=Medium Late, L=Late, PS=Photoperiod Sensitive.
2Means followed by the same letter do not significantly differ using LSD (P=0.05)
Table 4. Top hybrids in the 2017 UC Sorghum Forage Trials based on yield and lodging\(^1\).

<table>
<thead>
<tr>
<th>Hybrid</th>
<th>Company</th>
<th>Type</th>
<th>Maturity</th>
<th>BMR</th>
<th>% Lodging</th>
<th>Ton ac(^1) 65% Moist</th>
<th>% Crude Protein</th>
<th>240 hr NDFd</th>
<th>Milk Lbs ton(^1)</th>
<th>Rel. Forage Quality</th>
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<tbody>
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<td>Scott Seed Co.</td>
<td>F</td>
<td>L</td>
<td>Y</td>
<td>9.6</td>
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<td>7.58</td>
<td>60.8</td>
<td>1768.1</td>
<td>50.96</td>
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<tr>
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<td>Sorghum Partners</td>
<td>F</td>
<td>E</td>
<td>N</td>
<td>3.8</td>
<td>22.2</td>
<td>8.13</td>
<td>65.1</td>
<td>2595.6</td>
<td>98.77</td>
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<td>Dyna-Gro Seed</td>
<td>F</td>
<td>M</td>
<td>N</td>
<td>0.8</td>
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<td>10.18</td>
<td>60.3</td>
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<tr>
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<td>L</td>
<td>N</td>
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<td>ML</td>
<td>Y</td>
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<td>E</td>
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<td>ML</td>
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\(^1\)The top hybrid list was derived by taking those hybrids with the highest yields and eliminating those hybrids that lodged by more than 10%.
Table 5. Top yielding hybrids that yielded over 20.0 tons acre\(^{-1}\) averaged over the UC Forage Trials in 2017.

<table>
<thead>
<tr>
<th>Hybrid</th>
<th>Company</th>
<th>Type</th>
<th>Maturity</th>
<th>BMR</th>
<th>% Lodging</th>
<th>Ton ac(^{-1}) 65% Moist</th>
<th>240 hr NDFd</th>
<th>Milk Lbs ton(^{-1})</th>
<th>Rel. Forage Quality</th>
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<td>PS</td>
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<td>L</td>
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<td>26.2</td>
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\(^{1}\)Hybrid information provided by seed companies. F=Forage sorghum, ME=Medium Early, M=Medium, L=Late, E=Early, PS=Photoperiod Sensitive.