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## **Sorghum as a low-input crop for bioenergy, food and feed in California**

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## Project Summary

Sorghum is an annual crop that could be both a short-term and long-term solution for California's need for more drought-tolerant annual crops for use in food, feed, and renewable products and fuels. Drought continues to plague California growers and drought-tolerant crops, such as sorghum, can help farmers mitigate some of the water issues they faced in 2015 and beyond. Sorghum is a C<sub>4</sub> plant that is drought- and flood-tolerant and uses less fertilizer inputs than other crops, like corn, but which can respond very well to both additional irrigation and fertilizer.

Quantifying and estimating economic benefits of sorghum in California will assist producers in making wise crop choices for their farming operations in the future. Replicated field trials of sorghum have been planted throughout the State at various ANR Research Centers and at UC Davis. These were aimed at evaluating grain and forage sorghum's potential as an alternative cropping system that would provide greater water savings and a wide range of end-use products that could enhance farming systems throughout California.

The payoff of this research can already be seen in the Valley as more forage sorghums are being planted to offset the limited water that is available to dairy farms for forage production. In 2014, FSA estimated that approximately 85% of all forage grown in the valley was corn silage; however, in conversations with various dairy personnel and with forage silage choppers, this number is looking to change in the near future as dairy producers struggle with drought and water restrictions. Some of this shift can be attributed to the information provided through research and educational efforts of this UC-ANR research grant, and the subsequent research projects that are resulting from this work.

## Research Program

This project investigated sorghum as a low-input crop for the production of bioenergy, food and feed in California and had three broad goals: 1) to identify the best sorghum varieties for the production of bioenergy, food and feed in California, 2) conduct experiments to determine irrigation management responses and water use of forage and grain sorghum types in California, and 3) validation, calibration and implementation of crop production and economic models.

Results from the variety trial and water use research are being used to test the accuracy of the APSIM model (Agricultural Production Systems sIMulator) for predicting sorghum production and resource utilization (water, nutrients) in California production conditions. The model will then be used to determine how sorghum will behave under different irrigation and fertilization regimes, as well as under future climate scenarios.

## Results:

*Grain Evaluations:* Strong genotype by environmental (GxE) interactions were observed in the three years of grain research over the locations; however, GxE was random and therefore cultivar evaluation was based on mean performance and stability across all environments. For the most

part, grain yields were relatively stable, while R-0413 and KN8416 had yields slightly lower than the grand mean and were highly unstable across years and locations.

*Forage Quality and Bioenergy Potential:* Forage sorghum samples were taken at time of harvest from 4 locations around the state of California and analyzed for forage quality. This included research sites at UC Davis, WREC in Five Points, El Centro (DREC) and from two trials (early and late-planted crops) at KARE. NIRS was used to determine crude protein, ADF, aNDF, dNDF30, dNDF48 and TDN, among other quality parameters. NIRS involve grinding samples, scanning, managing calibrations, and doing wet chemistry to confirm the NIRS calibrations. Forage sorghums typically have crude protein values similar to corn, and ranged from 7.0 to 10.6 across the state. Crude protein (CP) ranged from 8.0% -10.2% for the late and early-planted trials, respectively, at KARE. Probably more important than CP is the fiber analysis and the fiber digestibility. Acid Detergent Fiber (ADF) ranged from 34.0%-42.1%, and amylose-Neutral Detergent Fiber (aNDF%) ranged from 57.0%-66.9% across locations.

Thus, as a forage, sorghum is quite higher in fiber concentration than many forages, and somewhat higher than corn, but not corn stover. BMR (Brown Mid-rib) types of sorghum on average have higher digestibility than non-BMR sorghums, but it is important to note that there are large variations within a type. Further work on digestibility of the fiber fraction (since it's so high as a percentage of the dry matter), and the issues associated with quality for biofuel production are undergoing further analysis. Differences in analysis between silage-processed sorghum and sorghum samples analyzed directly from the field are on-going.

*APSIM Modeling:* The APSIM program is highly customizable and past CIMIS weather data (California Irrigation Management Information System; [www.cimis.water.ca.gov/](http://www.cimis.water.ca.gov/)) from each of our locations, soil characteristics, soil water and nutrient levels, and select dates and amounts for management operations, such as planting, irrigating, and fertilizing, have been uploaded to the model. Preliminary testing with the APSIM model has been positive, especially for grain sorghum. It has accurately predicted the grain yield and maturity date from one of our past trials and it is being evaluated on other years and locations to see if further modifications are needed. The sweet sorghum model has promise for predicting results for forage sorghum, but more testing needs to be done. It is possible to write code to more accurately describe the particular sorghum varieties used in our trials, and this is being explored.

### Information Transfer/Outreach Program

California has been dealing with severe drought over the last 4 years and this has impacted the dairy industry that has relied on heavily irrigated corn silage for their dairy feed. Currently 400,000 acres of silage are produced to support the dairy industry, which is predominately planted to corn silage and alfalfa in the summer months. Prior to our research efforts beginning in 2011, approximately 20,000 acres of sorghum silage were planted in the California according USDA-FSA data. In 2015 those acres were reported to be approximately 55,871. Our outreach and extension efforts have provided information to farmers in the Valley, who have looked for forage options that use less water and provide an alternative, high quality forage. This is reflected

in the number of hits to the sorghum.ucanr.edu website, which have totaled over 6,000 since its launch in August 20, 2014.

We have been able to leverage this research into several new funded projects that build on some of the initial data and collaboration, which has allowed the UC sorghum group to expand into additional areas of drought and other research.

### Publications from prior projects

#### Media coverage:

- Kearney & West Side RECs: Studies of sorghum’s adaptation to drought push the frontiers of crop improvement  
(<http://californiaagriculture.ucanr.org/landingpage.cfm?article=ca.v069n04p208&fulltext=yes>)
  - Drought-resistant genes research (<http://californiaagtoday.com/drought-resistant-genes-research/>)
  - A spotlight on Sorghum (<http://ucfoodobserver.com/2016/03/01/a-spotlight-on-sorghum/>)
  - Drought-tolerant sorghum solid option as livestock forage  
(<http://westernfarmpress.com/miscellaneous/drought-tolerant-sorghum-solid-option-livestock-forage>)
  - Don’t treat forage sorghum like corn forage (<http://www.progressiveforage.com/forage-types/other-forage/don-t-treat-forage-sorghum-like-corn-forage>)
  - Valley Researchers to study how plants in drought change their genes  
(<http://kvpr.org/post/valley-researchers-study-how-plants-drought-change-their-genetics>)
  - It’s a bird, it’s a plane. No it’s a drone!  
([http://www.reedleyexponent.com/articles/2015/09/22/publications/parlier\\_post/news/doc5601c3d9f10ed796329218.txt](http://www.reedleyexponent.com/articles/2015/09/22/publications/parlier_post/news/doc5601c3d9f10ed796329218.txt))
  - Sorghum in “California Farm Equipment” written by Don Curlee
  - Drought in “UCLA Newspaper” interviewed by UCLA student reporter
  - Understanding the benefits of sorghum silage for California dairies  
(<https://www.youtube.com/watch?v=-TTETFwfz6s>)
  - KARE and Sorghum interview with “The Big Show” 1/15/13
  - California Ag and Sorghum interview with Doug Cooper with “The Big Show” 5/4/15
- Preview of “The Walking Dead” – searching for sorghum ([www.amc.com/shows/the-walking-dead/video-extras/season-06/episode-10/sneak-peek-episode-610-the-walking-dead-the-next-world](http://www.amc.com/shows/the-walking-dead/video-extras/season-06/episode-10/sneak-peek-episode-610-the-walking-dead-the-next-world))