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Starting with this issue, *California Agriculture* will publish a regular feature on projects at UC ANR's Research and Extension Centers

Kearney and West Side RECs: Studies of sorghum's adaptation to drought push the frontiers of crop improvement

With the climate changing and demands on water resources growing, crops that can survive drought are near the top of the global agricultural wish list. But drought tolerance has so far confounded plant researchers. One problem is that it involves many complex relationships: a host of genes that activate when a plant is short of water; soil microbes that interact with plant roots. Another difficulty has been that plants respond differently to water stress when they are grown outdoors rather than indoors, meaning that greenhouse-based findings haven't translated well to the field.

Two new research projects involving the Kearney and West Side Research and Extension Centers (RECs) are taking on these challenges, using a mul-

tifaceted, field-based approach with sorghum as their subject. The knowledge gained could lead eventually to the ability to control the mechanisms of drought tolerance and the development of improved varieties of sorghum and other crops.

"We may be able to find ways to manipulate those characteristics to enable drought tolerance and water use efficiency," said Kearney REC director Jeff Dahlberg. "That's the ultimate pie-in-the-sky goal."

The projects are funded by recent grants from the U.S. Department of Energy (DOE) — one from the Biological and Environmental Research (BER) Program and the other from the Advanced Research Project Agency-Energy (ARPA-E). The two DOE programs support the study of microbes and plants for sustainable biofuel production.

West Side REC director Bob Hutmacher collects a soil sample next to a sorghum plant to evaluate the microbial population around sorghum roots.



Sorghum, in addition to being a staple food grain in much of the world, is promising as a bioenergy crop and as a substitute for corn silage in livestock rations. It is a good candidate for improved drought tolerance in part because it already handles water stress better than many other crops, including its close relative, corn. The grain emerged as a food crop in drought-prone areas of Africa, and existing varieties exhibit a range of traits that help the crop endure periods of scarce water.

Peggy Lemaux, a UC ANR Cooperative Extension specialist based at UC Berkeley, is the principal investigator on the 5-year, \$12.3 million BER-funded project awarded in September. Using field plots of sorghum at Kearney and West Side RECs, the project will investigate what's known as the epigenetics of drought tolerance — the ways in which certain genes are activated in response to water stress, Lemaux said. These mechanisms, which allow rapid adjustments to stresses, can change the plant's physiology to better cope with reduced moisture.

The project also will investigate how microbes in the soil may interact with sorghum to enhance its drought tolerance. Compounds produced by microbes may act as signals, touching off epigenetic or other responses that help sorghum plants survive a long dry stretch, Lemaux said. Microbial populations also might enhance delivery of water and nutrients to a sorghum plant's roots and trigger them to produce enzymes and plant hormones that influence its growth and yield.

Lemaux noted that the BER project takes advantage of UC ANR's institutional structure, partnering campus-based Agricultural Experiment Station (AES) faculty and Cooperative Extension specialists with researchers based at the RECs. The project's collaborators also include a UC Berkeley faculty member in statistics and DOE researchers based at the Joint Genome Institute and the Pacific Northwest National Laboratory (PNNL). It's a powerful combination of laboratory and field expertise and resources, Lemaux said.

"We couldn't do it without them, and they couldn't do it without us," Lemaux said of the collaboration between campus- and REC-based researchers.

The ARPA-E grant, for \$3.3 million, is headed by PNNL researchers and will include significant work at the Kearney and West Side RECs, led by Dahlberg and West Side REC director Bob Hutmacher. The project will use aerial drones to gather high-resolution imaging data on test plots of multiple varieties of sorghum subjected to varying levels of drought stress.

The drone-based imaging should yield higher-quality data, in less time, on the test plants' physical characteristics, or phenotypes. Unlike many of the other processes in genetic research, which have been dramatically accelerated by automation, documenting plant phenotypes still involves a great deal of manual work. Faster phenotyping would expand the number of field tests and the amount of data that a research team can generate and analyze.

These two major projects build on a Kearney-based study begun in 2012 on the potential for wider-scale cultivation of sorghum in California as a food, feed and fuel crop. That work, led by Dahlberg and involving seven other UC ANR researchers, including Hutmacher and Lemaux, was funded by a \$596,000 grant from UC ANR.

Dahlberg became interested in sorghum in the early 1980s as a Peace Corps volunteer in Niger, where the crop is generally grown without irrigation. He chose to study sorghum for his dissertation research at Texas A&M and has been working on it ever since,



UC Berkeley researchers Devin Coleman-Derr and John Taylor collect soil samples to evaluate microbial populations in an undisturbed field.

bringing his interest in the crop to the Kearney REC when he joined as director in 2011.

Globally, sorghum is the fifth most widely produced grain, behind corn, rice, wheat and barley. It is currently a minor crop in California, grown on fewer than 100,000 acres, but there's reason to believe it will have a larger role in the future. It can be grown to yield grain or for biomass or silage production, and it is quite hardy, tolerating extremes of heat as well as waterlogging and drought. Such versatility is well suited to the sorts of extreme weather conditions that continued climate change is expected to bring. [CA](#)

Test plots at California State University Fresno contrast sorghum plants that have received 50% of their evapotranspiration demand (foreground) and those that have received 100% (right and background). While sorghum is highly drought tolerant, it still needs water. Both the timing and the amount of water applied influence the plant's development.

