ALARC Highlights
Summer 2019

USDA-Agricultural Research Service
Arid-Land Agricultural Research Center
Maricopa, Arizona

In this issue

Featured Accomplishment

Biological Control of Aflatoxins in Arid-Land Crops

Aflatoxins are highly carcinogenic compounds produced by the fungus *Aspergillus flavus* and its close relatives. *A. flavus* contaminates a large variety of crops—corn (Fig. 1), peanuts, tree nuts, figs, and some spices—whenever these crops are grown in warm climates, including the desert Southwest. Because aflatoxin contamination of food is strictly regulated and monitored, aflatoxins present an economic challenge to farming in the U.S., estimated at $500 million to $1.5 billion per year.

The Aflatoxin Reduction Lab (now part of the Arid-Land Agricultural Research Center but located in Tucson) has partnered with growers and grower organizations to try to bring biological control technologies to as many crops and regions as possible. Aflatoxin biological control works by spreading a food source (for example, sterilized grain) inoculated with specific, naturally occurring isolates of *A. flavus* that cannot produce aflatoxins. In the field, the biocontrol fungi grow on the grain, sporulate, and displace the naturally occurring aflatoxin producers from the crop. This technology was first developed and proven effective in cottonseed in Arizona, and that isolate (AF36), is now in commercial use (marketed as AF36 Prevail™). See Bandyopadhyay et al. (2016) for a recent review of biocontrol through the application of atoxigenic isolates as well as some issues that have arisen in our international collaborations.

Recently in partnership with the Texas Corn Producers and the Arizona Cotton Research and Protection Council (ACRPC), the lab has been participating in gathering and analyzing data from an Experimental Use Permit for a new biocontrol product to be used in Texas corn: FourSure™. The four atoxigenic isolates that are the active ingredients of FourSure™ were originally isolated in Tucson from Texas corn samples collected between 2008 and 2010. After verifying the ability of these isolates to decrease aflatoxin production, the EPA issued an Experimental Use Permit (EUP) to study FourSure™ on 5000 commercial acres in Texas per year for three years.

Fig. 1. Corn ear colonized by *Aspergillus flavus*.

In addition to looking for aflatoxin contamination and the displacement of other *A. flavus* strains on the crop by the FourSure™ isolates in treated versus untreated fields, the proportion of these isolates was also examined in soils before application and in the soils the following spring. Analysis is complete for samples collected in 2017, the first year of the EUP, and

aflatoxin was significantly lower in treated fields (mean aflatoxin = 5.1 ppb) than in control fields (mean aflatoxin 49.1 ppb). In addition, much higher levels of the FourSure™ isolates were seen in corn from treated fields as well as in the soils of treated fields collected in Spring 2018 (Fig. 2) when compared to fields not treated with FourSure™. For context, the regulated level for aflatoxin in human food is 20 ppb and 0.5 ppb for milk.

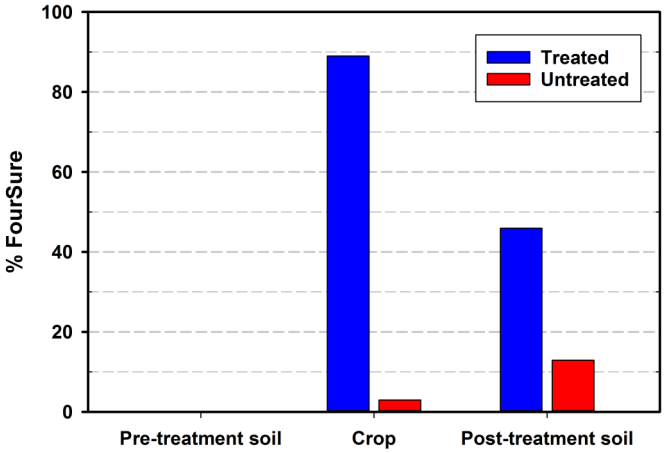


Fig. 2. Percentage of all *A. flavus* isolates found in samples. Pre-treatment soil samples were taken in Spring 2017; post-treatment soil samples taken in Spring 2018 before any biocontrol products had been applied for that year. No FourSure™ isolates were seen in the pre-treatment soil samples from 2017.

Also, in collaboration with ACRPC, the Aflatoxin Reduction Lab began a small-scale initial study of silage corn in Arizona. When dairy cows eat feed contaminated with aflatoxin, some of that aflatoxin ends up in milk, where regulations are much more stringent than in other food. Dairies have asked their silage growers to treat their corn with a biocontrol product like AF36 Prevail™, but effective application methods for silage are unknown.

To test whether the AF36 isolate could be found on to silage corn, four to nine samples per field were taken from three silage fields (two in Goodyear, AZ and one in Tonopah, AZ) during harvest in 2018. Multiple samples were taken per field to compensate for the great variability seen in these fields. Other crops can be thoroughly mixed after collection to compensate for this, but sampling needed to be separate to verify whether such post-collection mixing could be performed for silage.

Preliminary results show high amounts of *A. flavus* spores on the silage corn (in the range of 10^7 – 10^9 spores per gram of sample; Figure 3). For comparison, mature corn harvested in Texas in 2018 had 10^7 spores per gram of sample, while cotton seed from Goodyear and Tonopah in 2000 and 2001 had 10^2 spore per gram. Identification of the fungi found on the silage is continuing, but there are sufficient results from two of the fields to see a large percentage (78-85%) of the isolates are the biocontrol isolate AF36. These results indicate that biocontrol is making it onto the silage crop in the field, but further study is needed to determine the best times and application methods to control aflatoxin in the final silage product. (Contact: Ken.Callicott@ars.usda.gov)

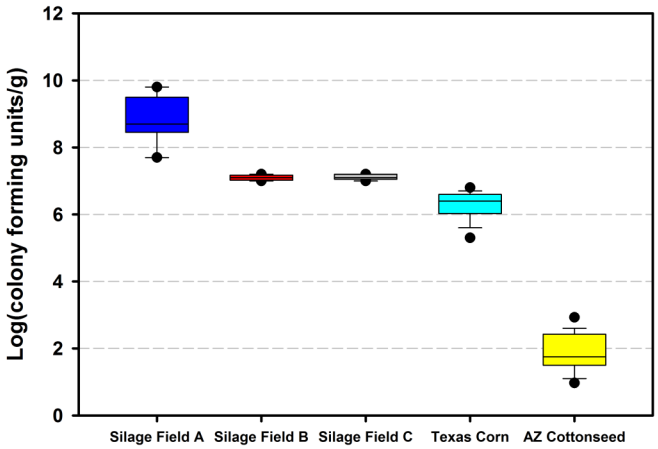


Fig. 3. Density of *A. flavus* fungi from various sources.

Suggested Reading

Bandyopadhyay, R., A. Ortega-Beltran, A. Akande, C. Mutegi, J. Atehnkeng, L. Kaptoge, A. L. Senghor, B. N. Adhikari, and P. J. Cotty. 2016. Biological control of aflatoxins in Africa: current status and potential challenges in the face of climate change. World Mycotoxin Journal 9: 771-789. (PDF)

The Aflatoxin Reduction Laboratory joined the Arid-Land Agricultural Research Center in October 2018. Prior to that the laboratory was associated with the USDA-ARS New Orleans

Other Accomplishments

Improving estimates of maize water use. To accurately simulate crop water use, models must account for how many days of growth can occur following a rain or irrigation event before the soil water supply is exhausted. Under the umbrella of the Agricultural Model Intercomparison and Improvement Project (AgMIP), an inter-comparison test was organized using eight years of water use or evapotranspiration (ET) measurements collected by an ARS researcher at Ames, Iowa as the standard. A retired ARS collaborator at Maricopa, Arizona, compiled comparisons of evapotranspiration (ET) predictions from 29 models from 28 research groups around the world. In the first "blind" phase for which only weather, soils and management information were furnished to the modelers, estimates of seasonal ET varied from about 200 to about 700 millimeters, and in subsequent phases, the range of ET predictions, as well as yield, remained large. Nevertheless, several models performed substantially better than the median for predicting ET and grain yield. Approaches used in the better models indicate options for improving all the models and ultimately, estimations of crop water use, strengthening management and policy decisions by stakeholders. **Contact**: Bruce.Kimball@ars.usda.gov

Phenotyping platforms provide insights into the genetic control of drought tolerance. ARS researchers in Maricopa, Arizona, along with scientists at the University of Arizona and the University of Bologna in Italy, studied imagery from two Unmanned Aerial Vehicles (UAVs) or drones

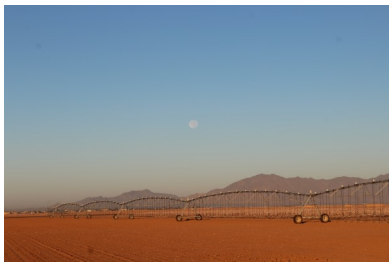
and data from tractor-mounted instruments for a panel of 248 elite durum wheat accessions grown in Maricopa and measured at different growth stages, under varying water regimes. The UAV-based data explained a larger fraction of variation in crop growth as characterized by the normalized difference vegetation index (NDVI), especially under drought stress. In total, 46 significant genetic regions affected NDVI across sensor platforms, with 22 loci showing associated effects on leaf greenness, two on leaf rolling and ten on crop biomass. Results demonstrate that relatively low-cost UAVs are effective tools for monitoring crop growth, including specific genetic responses to drought, greatly increasing the ability of crop breeders and geneticists to dissect physiological responses and select for improved adaptation to drought. **Contact:** Jeffrey.White@ars.usda.gov

Discovery of a new protein that modulates oil content in plants. Oilseed crops synthesize and store large amounts of oil (up to 40 percent dry weight) in their seeds, which serves as a carbon and energy reserve for germinated seedlings and an important nutritional resource for humans and animals. Enzymes for oil synthesis in plants are generally well understood, but the processes involved in the packaging of oil into subcellular organelles called "lipid droplets" are relatively unknown. An ARS researcher in Maricopa, Arizona, collaborated with researchers at the University of North Texas, Denton, Texas, and the University of Guelph, Ontario, Canada, to identify a new protein called Lipid-Droplet Associated Protein – Interacting Protein (LDIP) that plays a key role in the formation of lipid droplets in plant cells. Disruption of the LDIP gene resulted in much larger lipid droplets and up to 10 percent more oil in the leaves and seeds of plants. These results open the door to the use of non-transgenic mutational breeding strategies for identifying plant lines that harbor mutations in this gene. This breakthrough will benefit scientists studying the basic mechanisms of oil formation in plants as well as scientists and breeders working to develop elite oilseed cultivars with increased oil content. **Contact:** John.Dyer@ars.usda.gov

Characterization of genetic diversity in a USDA guayule germplasm collection. Guayule (*Parthenium argentatum*) is a woody perennial shrub native to the desert regions of northern Mexico and southwestern United States that produces natural rubber in its bark tissues. Attempts to increase rubber yields through crop breeding, however, have been hampered by a lack of well characterized germplasm. ARS scientists in Maricopa, Arizona, along with scientists at Cornell University, Ithaca, New York, and West Virginia University, Morgantown, West Virginia, performed a detailed assessment of all publicly available guayule germplasm, including closely related species and interspecific hybrids. Use of a combination of next generation sequencing technologies and phylogenetic approaches clearly determined the genetic identity and relationships for each accession. Overall, these data help to identify specific lines that can be used for crop breeding, identify geographical regions that should be explored to obtain additional genetic diversity, and provide robust molecular tools to enable genomics-assisted crop improvement. These newly developed methods represent a substantial step forward in the development of guayule as an alternative, commercial source of natural rubber. **Contact:** Hussein.Abdel-Haleem@ars.usda.gov

Comparison of evapotranspiration methods in Cotton2K model. Improved irrigation management is needed to conserve limited water resources in the western U.S. One option is to enhance agroecosystem models, which calculate daily plant growth and crop water use based on local soil and weather conditions. Accurate simulation of evapotranspiration (ET) in these models is necessary to realize improved irrigation recommendations. Using data from three cotton growing seasons in Bushland, Texas, ARS researchers at Maricopa, Arizona, Fort Collins, Colorado, and Bushland, Texas, developed a computational approach to intercompare three ET methods in the Cotton2K agroecosystem model. Three ET methods led to differences in simulation accuracy for ET, soil water content, and several plant growth metrics. However, no ET method could consistently outperform both of the other two ET methods when collectively considering 22 measured metrics of the agroecosystem. Improvements to the Cotton2K simulation methodologies for soil water flux near the soil surface and for linking water use with crop growth are the first steps to make the model better simulate cotton production in the western U.S. **Contact:** Kelly.Thorp@ars.usda.gov

Nitrogen (N) management practices for surface irrigation (SI) and overhead sprinkler-irrigated (OSI). Nitrogen management recommendations for cotton in central Arizona have not been updated for more than 20 years, and there are no specific guidelines for OSI. Nitrogen management practices for SI and OSI were evaluated and improved in a four-year study by ARS scientists in Maricopa, Arizona. The guidelines developed include the use of soil testing and canopy reflectance measurements to guide in-season N management. When implemented by growers, substantial savings of N fertilizer can be achieved without changing yields. **Contact:** Kevin.Bronson@ars.usda.gov



Removal potential of tylosin from water using diatomaceous earth (DE). Tylosin is a widely used antibiotic fed to animals during livestock production with most of the antibiotic passing through the animal unchanged and entering the environment where it might contribute to antimicrobial resistance. ARS researchers at Maricopa, Arizona and Clay Center, Nebraska found that a common clay mineral, diatomaceous earth (DE), could remove tylosin from wastewater. Removal of tylosin from the wastewater was measured and two different sorption models were evaluated under different environmental conditions (e.g. temperature, type of salinity, ionic strength). One of the models was better at describing the binding and predicted that the amount of tylosin that binds to DE was dependent on the types of salts added and the temperature of the water. From previous data on the concentration of tylosin in beef cattle storage ponds, removal of tylosin by sorption to DE would cost $0.25 per million gallons of storage pond water and could provide a cost-effective way to remove tylosin from wastewater produced by beef cattle operations. **Contact:** Clinton.Williams@ars.usda.gov

New mechanism of resistance to Bt crops involves mis-localization of cadherin protein receptor. Bt crops are named for *Bacillus thuringiensis* (Bt), a bacterium that protects crops by naturally producing a crystal protein that is toxic to many pest insects. Bt crops are genetically engineered to produce the same toxin as Bt in every cell of the plant, with the goal of protecting the crop from pests. Pink bollworm, a common cotton pest, have become resistant to the toxins of Bt cotton via mutations to the cadherin proteins that are thought to prevent toxin binding to the insect midgut. ARS scientists in Maricopa, Arizona, and researchers from China and the University of Arizona demonstrated that cadherin mutations affect protein trafficking and therefore reduced binding of the toxin due to the loss of an available receptor. Mutations that affect various regions of the cadherin protein can alter expression on the cell surface, which may be a common underlying mechanism promoting the development of resistance to Bt crops, in addition to mutations that directly affect toxin binding. Results are valuable for scientists concerned with understanding the mechanisms of resistance, for biotechnology companies developing new strategies to target pests, and for government authorities responsible for regulating transgenic crops. **Contact:** Jeff.Fabrick@ars.usda.gov

Development of a novel non-destructive marking technique for tracking bees. Studies of bee movement and activities across a landscape are important for developing an understanding of their behavior and their ability to withstand environmental stress. Recent research has shown that proteins, are effective for mass-marking bees; however, current techniques require sacrificing individual bees during data collection. ARS scientists in Logan, Utah, and Maricopa, Arizona, developed a nonlethal sampling method for protein mark-capture research on bumble, blue orchard, and leafcutter bees. The technique consists of catching marked bees in the wild, immersing them momentarily in a buffer to extract any potential egg albumin mark, and then releasing them. Results showed that an egg albumin-specific assay was 100 percent effective at detecting the protein on bees and did not have an impact on bee survivorship. These methods are currently being used throughout the U.S. to study the dispersal patterns of these important pollinators. **Contact:** James.Hagler@ars.usda.gov

Retrospective Analysis of a Classical Biological Control Program. Classical biological control has been a key technology in the management of invasive arthropod pests globally for over 120 years, yet rigorous quantitative evaluations of program success or failure are rare. An ARS scientist in Maricopa, Arizona, used long term (15 years) life table data and matrix model analyses to quantitatively assess a classical biological control program for the sweetpotato whitefly, a key invasive insect pest in the western U.S. Analyses showed that the introduction of two parasitoid species failed to increase mortality or reduce population growth of the pest in cotton. Instead, native arthropod predators were found to inflict heavy mortality on the pest and are the key to managing this insect in western cotton production systems. The research demonstrated a robust approach to assessing biological control programs and will be of interest to researchers and policy makers involved in developing and implementing classical biological control programs globally. **Contact:** Steve.Naranjo@ars.usda.gov

Routine use of atoxigenic strains of *Aspergillus flavus* for biological control of aflatoxins. Utilizing atoxigenic strains of *A. flavus* has become routine in the U.S. and several portions of Africa, including Kenya for control of aflatoxins. An ARS researcher at Tucson, Arizona, performed a large population genetic analysis on *A. flavus* isolated from soil obtained from Kenyan maize fields. The study determined that *A. flavus* populations are very large, ancient, and evolving through mutation-driven, clonal reproduction. Under all conditions, all genetic loci were in linkage disequilibrium suggesting that atoxigenic *A. flavus* biocontrol agents used to modify fungal communities to produce fewer toxins, and thus be less dangerous, have remained genetically stable over thousands of years and should remain stable without sexual reproduction that would introduce new gene combinations. This novel and very effective biocontrol technology provide a simple inexpensive tool for improving the value and safety of crops and the environment. **Contact:** Ken.Callicott@ars.usda.gov

Recent Professional Awards and Recognition

Dr. Kelly Thorp is the recipient of the 2019 Soil Science Society of America, L.R. Ahuja Ag Systems Modeling Award. He is recognized for his research integrating agricultural system models with field research to enhance, extend, and transfer the experimental results. He will be honored in November this year at the annual Tri-Society conference in San Antonio, TX.

Dr. Alison Thompson received a 2018 Innovation Fund Award ($25,000) from the ARS Administrator for her proposal on high throughput phenotyping that will focus on enabling research on proximal sensing and image analysis, including the development of a new image processing pipeline and the usage of artificial intelligence algorithms for flower characterization.

Drs. Eduardo Bautista and Kevin Bronson had their paper selected to be featured in the Editor's Choice section of the *Journal of Irrigation and Drainage Engineering* (PDF)

Dr. Kevin F. Bronson received the 2018 Werner L. Nelson Award for Diagnosis of Yield-Limiting Factors from the American Society of Agronomy. Dr. Bronson was honored at the Annual Meeting of the ASA in November of 2018.

Dr. Bruce Kimball (retired ARS Collaborator, pictured with ARS Administrator Chavonda Jacobs-Young) was elected as an AAAS Fellow for outstanding contributions toward understanding crop responses to global climate change. He was honor at the annual AAAS meeting in February in Washington, D.C.

Drs. Andy French and **Kelly Thorp** received a 2019 Innovation Fund Award ($25,000) from the ARS Administrator for their proposal on advancing water management and conservation in irrigated arid lands that will use satellite data to power a phone app enabling better irrigation decisions for growers and crop consultants.

Dr. Steven Naranjo received the 2018 Distinguished Scientist Award from the International Organization of Biological Control (IOBC), Nearctic Regional Section. The award recognizes the outstanding contributions to furthering the science and implementation of biological control. He presented a lecture and was honored at the Entomological Society of America meeting in Vancouver in November 2018.

ALARC was recognized by USDA for their significant contributions to research that enabled the eradication of the pink bollworm from the USA and northern Mexico. The award was presented to ALARC at a ceremony at the Arizona Department of Agriculture in Phoenix in October 2018. (also see ALARC in the News below)

Current Grant Awards (*new)

*High-throughput phenotyping using portable LIDAR, Cotton Incorporated (PI **Andy French** with Co-PIs Michael Gore, **Alison Thompson**) 2019

*Nitrogen fertilizer management for newer cotton cultivars under overhead sprinkler irrigation, Cotton Incorporated (PI **Kevin Bronson**) 2019

*Evaluation and improvement of crop simulation models to meet the data needs of modern cotton production systems, Cotton Incorporated (PI **Kelly Thorp**) 2019

*Borlaug Fellow mentoring in remote sensing for crop production estimation, USDA Borlaug Fellowship Program (PI **Kelly Thorp**) 2018-2019

*Evapotranspiration mapping and validating over Yuma, AZ, Jet Propulsion Lab,NASA (PI Simon Hook, CO-PI **Andy French**) 2018-2019

*Occurrence and treatment of unregulated organic micropollutants in the San Jaun River, US Bureau of Reclamation? (PI Anthony Kennedy, Co-PI **Clinton Williams**) 2019-2020

*Mentoring agricultural students through training, experiential leaning and research skills (MASTERS) for the future agricultural workforce, Texas A&M University (PI Catherine Simpson, CO-PI **Clinton Williams**) 2018-2019

*Yuma Valley environmental sampling and surveillance for bacterial foodborne pathogens, Food and Drug Administration (PI: Channah Rock, CO-PI **Clinton Williams**) 2019-2020

*Genetics and mechanism of pest resistance to second generation Bt crops, USDA-NIFA (PI Bruce Tabashnik, Co-PIs **Jeff Fabrick,** Yves Carriere) 2018-2021

*Pinpointing life-stage predation events on *Lygus hesperus*, Arizona Cotton Growers Association, Arizona Cotton Research and Protection Council (PI **James Hagler**) 2019

*Optimization of gene silencing/editing techniques in *Lygus hesperus*, Cotton Incorporated (PI **Colin Brent**, Co-PIs **Jeff Fabrick, Joe Hull**) 2019

*Improving insect management strategies in Arizona Cotton, Arizona Cotton Growers Association. (PI Peter Ellsworth, CO-PI **Steve Naranjo**) 2019

*Designing and evaluating sustainable cotton systems with reduced pest and pesticide risks, Cotton Incorporated. (PI Peter Ellsworth, CO-PIs **Steve Naranjo**, Al Fournier) 2019

*Applying proximal sensing to enhance upland cotton yield trials, Cotton Incorporated (PI **Alison Thompson**) 2019

Monitoring evapotranspiration, crop growth and nutrient stress over irrigated crops in central Arizona, NASA (PI **Andrew French**, Co-I **Kevin Bronson, Kelly Thorp**, Pedro Andrade-Sanchez) 2017-2020

Root genetics in the field to promote drought adaptation and carbon sequestration, Dept. Energy, ARPA-e Program (PI John McKay, Parker Antin, Randy Bartels, Thomas Borch, Pedro Andrade Sanchez, Francesca Cotrufo, **Andrew French**, Michael Ottman, Sangmi Palickara, Keith Paustian, Patrick Schnable, Chris Topp, Chris Turner, Matthew Wallenstein, Jianming Yu) 2017-2020

Securing water for and from agriculture through effective community & stakeholder engagement, USDA-NIFA (PI Kathy Brasier, CO-PIs **Clinton Williams**, Sarah Porter, Julia Bausch and others) 2017-2020

Quantitative assessments of water and salt balance for cropping systems in Lower Colorado River Irrigation Districts, Dept. Interior, Bureau of Reclamation (PI **Andy French**, CO-PIs Charles Sanchez, Paul Brown, Dawit Zerihun, **Eduardo Bautista, Clinton Williams**) 2016-2019

Bumble bee foraging and colony dynamics in agricultural landscapes, USDA-NIFA (PI James Strange, CO-PIs Knute Gundersen, Rufus Isaacs, **James Hagler**, Brynja Kohler) 2017-2020

Empowering producers to effectively integrate chemical and biological controls through research and outreach on selective chemistries and impacts on natural enemies, Western Region SARE, USDA-NIFA (PI Isadora Bordini, CO-PIs Peter Ellsworth, **Steve Naranjo**, Al Fournier) 2018-2019

Enhancing IPM by integration of chemical and biological controls through assessment of selectivity of chemistries and function of biocontrol, Western IPM Center Grant Program, USDA-NIFA (PI Isadora Bordini, CO-PIs Peter Ellsworth, **Steve Naranjo**, Al Fournier) 2018-2019

Utilizing genes from the soybean germplasm collection to mitigate drought stress, United Soybean Board (PI, Larry Purcell, CO-PIs **Hussein Abdel-Haleem**, Felix Fritschi, Jason Gillman, James Smith, Jeff Ray) 2018-2022

Sustainable bioeconomy for arid regions, USDA-NIFA (PI Kimberly Ogden, Co-PIs Dennis Ray, Peter Waller, Raina Maier, Istvan Molnar, Meghan Downes, William McCloskey, Trent Teegerstrom, Omololu Idowu, Paul Gutierrez, Kulbhushan Grover, F. Omar Holguin, Catherine Brewer, Sangamesh Angadi, **Hussein Abdel-Haleem**, Colleen McMahan, David Dierig, Amy Landis, Jason Quinn, Xianglan Bai, Karl Seck) 2017-2022

Genomics and phenomics to identify yield and drought tolerance alleles for improvement of camelina as a biofuel crop, USDA-NIFA. (PI **John Dyer**, Co-PIs **Hussein Abdel-Haleem**, Daniel Schachtman, Yufeng Ge, Toni Kutchan, Noah Fahlgren) 2016-2019

Energy sorghum reference phenotyping system, DOE-ARPA-E (PI Todd Mockler, CO-PIs Noah Fahlgren, Erica Fishel, Stephen Kresovich, Jeremy Schmutrz, Jesse Poland, Geoff Morris, William Rooney, Pedro Andrade, Mike Ottman, **Jeff White**, David LeBauer, Robert Pless, Roman Garnett) 2015-2019

Elucidating the cellular machinery for lipid storage in plants, DOE-BES (PI Kent Chapman, CO-PIs **John Dyer**, Robert Mullen) 2016-2019

Employee Engagement

ALARC held its **Annual Thanksgiving Potluck.** This is a yearly tradition at the Center, which brings together current, former, and retired employees, as well as family and friends. Everyone enjoyed wonderful food while catching up with friends and colleagues.

Brenda Singleton, Mike Roybal and Dale Spurgeon organized several **employee engagement programs** and listening sessions this past spring. The events included several TED talks and presentations prepared by Brenda and Mike. Employees enjoyed pizza and sub sandwich lunches after the events. Listening sessions for technicians and scientists focused on low rating elements of the recent Federal Employee Viewpoint Survey.

Jeff Fabrick is the Center's representative on the **PWA Employee Engagement Committee**. The goal of the committee is to report engagement activities that can be featured on AXON, ARS' intranet, and to generate and share employee engagement ideas that could potentially be implemented at the Location, Area or even Agency level.

Again this year we used **Administrative Professionals Day** to celebrate and thank all ALARC employees. Everyone enjoyed a pizza party hosted by the Center's RLs, CD and AO.

ALARC held its 4th Annual **Safety Poster Contest** as a fun way to highlight the importance of safety in the workplace. Employees voted to determine the winners. All the posters are hanging in the laboratory building. ***Special thanks*** *to Brenda Singleton for organizing the contest and Mike Roybal for printing the posters.*

1st Place
Colin Brent

2nd Place
Suzette Maneely

3rd Place
Sharette Rockolt

3rd Place
Amber Dearstyne

ALARC IN THE NEWS

Pink Bollworm Eradicated from the USA and Northern Mexico. After a 16 year program implemented in three phases across the southwestern USA and the three northern states of Mexico, the pink bollworm was declared officially eradicated in October of 2018. The pink bollworm is a global pest of cotton and invaded the USA more than 100 years ago where it was responsible for millions of dollars in damage every year. The eradication program was a partnership among cotton growers, state departments of agriculture, and USDA. ALARC and one of its founding predecessors, the Western Cotton Research Laboratory in Phoenix, was instrumental in developing many of the technologies such as sterile insect release, pheromone mating disruption, and Bt cotton resistance management that made the program possible. [link] [link]

Benefits of Some Genetically Engineered Seeds Extend Beyond Pest Control. Genetically engineered crops that produce the insecticidal proteins of a common bacteria (*Bacillus thuringiensis*, Bt) may enable biological control to function better because of the reduction in broader-spectrum insecticides once needed to control major pest insects now controlled by the plant. A recent study published by an ALARC scientist and colleagues suggest that biological control may help control the target pests and also other pests not susceptible to the Bt proteins. [link]

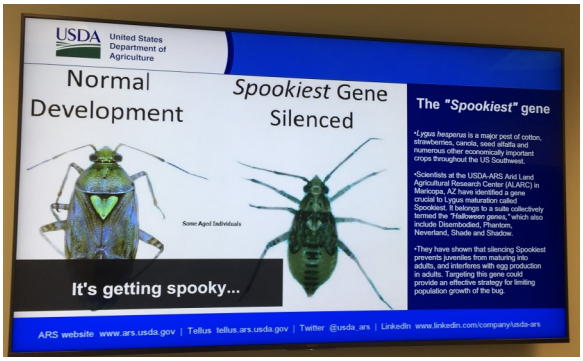
Public-Private Partnership to Solve Real Time Agricultural Problems. An ALARC scientist is collaborating in research to use remote and proximal sensing technology to improve irrigation efficiency in vegetable crop production in Yuma. [link]

Enhanced Crop Breeding through High Throughput Phenotyping. Scientists from ALARC were featured in the Maricopa Monitor for their work on using proximal sensing technologies to measure crop health during periods of heat and drought stress. Using this data along with the genetics of the plants can identify candidates for crop improvement through selective breeding. [link]

Project Puente Student Interns. ALARC once again hosted a number of high school and college undergraduate interns as part of Project Puente with Central Arizona College. Students spent 8 weeks with a mentor scientist and completed their own research projects. Internships were capped with students presenting their poster at a special event. [Link] Dr. Crystal McKenna presented a TEDx talk at Central Arizona College that explores the changing faces of scientists and talks about Project Puente as a vehicle to increase diversity in STEM fields [link]

Tools for Entomological Research. Two ALARC scientists along with several other USDA-ARS scientists have published a special issue in the journal *Annals of the Entomological Society of America* focused on innovative tools for studying insect behavior and biological control. The tools include insect flight mills for the study of insect flight behavior and proteins markers for tracking insect movement and for understanding insect diets and feeding patterns in the field. [link]

Spookiest Gene for Halloween. The research of several ALARC scientists was featured at the USDA-ARS George Washington Carver building in Beltsville during Halloween. The research discussed various insect genes with fun Halloween themed names, including one called *Spookiest* that if silenced by RNAi keeps immature Lygus bugs from becoming adults and disrupts egg production in adults.



Growing Crops with Less Water. Scientists from ALARC were featured in the Maricopa Monitor for their work on using proximal sensing technologies for accurately assessing the water needs of crops such as cotton. Combining these data with simulation models can help to predict how much water the crop will need for optimal growth during the season. [link]

ALARC Student HTP Team. In early May, a group of interns from Central Arizona College presented some of the work they've been involved with at ALARC focused on high throughput phenotyping (HTP) data processing and database development. Also see Outreach and Events below. [link]

ALARC Seminar Series. Each year, ALARC hosts scientific seminars on a variety of topics related to entomology, plant science and water management. The series runs from September through May on a biweekly schedule on Monday afternoons. To get advance notice of seminar speakers and topics please email steve.naranjo@ars.usda.gov and we will get you on the notification list

Recent Events and Outreach

May 2018, The ALARC Equal Employment Opportunity (EEO) Committee celebrated Women's History month by presenting three Technology, Entertainment, Design (TED) Talks. TED Talks are in the form of short and powerful presentations by speakers who are doing cutting edge work across numerous causes and provided under the slogan "ideas worth spreading." The video presentations included, Billie Jean King, "*The Battle of the Sexes*", "*Why Gender Equality is good for everyone – men included*", and "*Violence Against Women – it's not a Men's Issue*." Employees enjoyed snacks during the program.

June 2018, 2019, ALARC hosted the annual Summer Ag Institute (SAI) group, which are made up of K-12 teachers that embark on a week-long tour throughout Arizona to learn about agriculture. This adventure is designed to teach them about food and fiber production, so they can incorporate that knowledge in the classroom curriculum. This experience is a great opportunity for the teachers to see the vital role agriculture plays in rural communities and the importance of the research being conducted at our center. The group had the opportunity to tour various labs in our three research units, learning about plant breeding, genomics, molecular biology, pest management, and water conservation. The tours were provided by scientist and technicians from all three units.

June 2018, ALARC EEO committee hosted and Lesbian, Gay, Bi, Transgender, and Questioning (LGBTQ) event that included three short videos, which were "*Beyond Granite: The AIDS Memorial Quilt*", which is a memorial that recognizes all those who have died from AIDS, "*How the Stonewall Riots Sparked a Movement*", which was a violent protest that erupted outside of Stonewall Inn in New York City, a defining moment for the LGBTQ community, and "*The Cultivating Change Summit*", which was an effort to bring together LGBTQ agriculturists in and around agriculture communities for the most unique professional development conference ever.

June-July 2018. ALARC scientists from all three units hosted a total of 15 students (science and IT) during the third year of Project Puente (Bridge), a USDA-NIFA funded program conducted in partnership with Central Arizona College (CAC), a Hispanic Serving Institute. The program gives each student an opportunity to conduct their own research project while learning about lab safety, data entry, strategies for working in the field, and the importance of maintaining a good laboratory notebook during the 8-week internship. The students produced scientific posters and presented them during an Intern Pizza Party, as well as at the closing ceremony. Students earned three college-level credits while engaged in a unique learning opportunity. ALARC scientists have been actively involved in training and mentoring underrepresented students in programs since 2012. ALARC will host 8 interns this summer.

August 2018, ALARC hosted Steve Smith, Arizona State Senator, District 11, who was invited by the President/CEO of the Beacon Group, a non-profit organization that provides employment opportunities for over 1,600 people in Arizona with disabilities. The Beacon Group provided custodial services to ALARC until early 2019. The visit was an opportunity to discuss the wide array of employment choices to successfully work with a disability. Dr's. John Dyer, Plant Physiology & Genetics Research Unit, Kevin Bronson, Water Management & Conservation Research Unit, and Colin Brent, Pest Management & Biocontrol Research Unit shared with Senator Smith several of our on-going projects in support of sustainable agricultural systems.

September 2018, ALARC scientist, Dr. Andrew French, Water Management & Conservation Research Unit, is an adviser for a Senior Design Project at Arizona Western College. The project objective is to design and build a drone-based thermal infrared imaging system useful for assessment of agricultural crop water use. Dr. French meets with students and their adviser frequently, to listen, advise, and assess progress on project implementation.

October 2018, ALARC scientists hosted a group from the City of Maricopa, Maricopa Advocate Program. The group was given a "behind the scenes" look at cutting edge research happening right here in the community. Ongoing research topics included water conservation, entomology, pest control, and development of natural rubber from the desert native Guayule bush. Tours were also provided for the Linear Move Sprinkler system and TERRA-REF field phenotyping scanner system.

December 2018. ALARC hosted its annual visit from a group of agricultural students and faculty from the University of Chapingo, Chapingo, Mexico. The group consisted of about 20 Irrigation Engineering students, and several faculty members. Dr. Eduardo Bautista discussed ongoing research at ALARC in the areas of irrigation modeling, surface irrigation, and remote sensing in irrigated agriculture. Tours were given of the linear move sprinkler system, phenotyping field scanner and a phenotyping tractor. This was a great opportunity for the students to meet our scientists, and see the research being conducted.

December 2018, ALARC hosted representatives from the City of Maricopa's Economic Development Department. The Economic Development Department leads the City's business attraction and retention efforts and is the point of contact for individuals seeking local assistance with site selection, market/demographic information, and business resources. A tour of the facility was provided by Dr's. Colin Brent, Pest Management & Biocontrol Research Unit, Alison Thompson, Plant Physiology & Genetics Research Unit, and Eduardo Bautista, Water Management & Conservation Research Unit.

January/June 2019. ALARC convened its semi-annual Stakeholder meetings in January (postponed due to the Federal government shutdown) and June in Maricopa, AZ. Stakeholders learned about the research going from ALARC scientists on topics ranging from monitoring cotton water use with drones, using high throughput phenotyping to advance cotton breeding and use of atoxigenic fungi to control aflatoxin

producing fungi in crops. During the June meeting we also heard from Brian Wong, one of our stakeholder members on their mushroom production operation. The meeting goals are to provide our stakeholders a venue to offer ideas and suggestions on research direction at the Center and to maintain strong relationships between scientists and the stakeholders they serve at the local, regional, and national level. Members represent growers, industry, university and state and federal agency interests.

February 2019. Due to the prolonged Federal government shutdown in December and January, ALARC's annual outreach event, Farm Science Day, was cancelled. The annual event is a Signature Event of the statewide AZ SciTech Festival and draws about 700 visitors brought from Maricopa, Casa Grande and the Phoenix metro area to learn about agriculture and the science behind agriculture. We look forward to hosting the event again in 2020.

April 2019. Sarah Beebout, the new National Program Leader for National Program 216 (Sustainable Agricultural Systems Research) visited ALARC to meet the scientists and learn about on-going projects in this topic area and in Natural Resources and Sustainable Agricultural Systems more generally. Sarah toured the linear move irrigation system, high throughput phenotyping platforms and projects and TRACE (Thermal Regime Agronomic Cereal Experiment).

April 2019. ALARC employees celebrated **Earth Day** with a series of videos produced by the American Museum of Natural History that compared global changes in 2017, 2018 and 2019 to 1970, the inaugural year of Earth Day.

May 2019. ALARC IT specialist Mike Roybal and Research Geneticist Alison Thompson organized a student seminar highlighting projects by seven IT and Plant Physiology and Genetics Research Unit interns that focus on high-throughput phenotyping (HTP). The students are past and present participants of Project Puente (Bridge), a USDA-NIFA funded program conducted in partnership with Central Arizona College (CAC), a Hispanic Serving Institute. Each student spoke for 5-7 minutes on the hardware, software, and/or IT support project they have been working on. Hardware talks focused on development of autonomous field robots and optimization of remote controlled field carts; software on data processing pipelines and database development; IT support on developing high performance computing clusters and server maintenance. Mike Roybal and Alison Thompson have been mentoring the ALARC student HTP team since 2016.

May 2019. The ALARC EEO Committee hosted a luncheon to observe Asian and Pacific Islander Heritage Month. The food served was sandwiches made with banh mi, the Vietnamese version of the French baguette. Bahn mi became a staple food by the early 20th century when Vietnam was part of French Indochina. Three videos were shown that featured Vietnamese entrepreneurs that are making indelible marks on the world around them through their own cultural voices, identities and experiences including Jenni Trang Le – Film, Food and Love, Duong Khach Linh – Music is a Universal Language, and Linda Mai Phung – Fashion Designer.

Recent Journal Publications

Water Conservation

Bronson, K.F., Hunsaker, D.J., Williams, C.F., Thorp, K.R., Rockholt, S.M., Del Grosso, S.J., Venterea, R.T., Barnes, E.M. 2018. Nitrogen management affects nitrous oxide emissions under varying cotton irrigation systems in the Desert Southwest, USA. Journal of Environmental Quality, 47:70-78. (PDF)

Brunetti, G., Simunek, J., **Bautista, E.** 2018. Hybrid finite volume-finite element model for the numerical analysis of furrow irrigation and fertigation. Computers and Electronics in Agriculture. 150:312-327. DOI: 10.1016/j.compag.2018.05.013

Chen, X., **Thorp, K.R.**, Ouyang, Z., Hou, Y., Li, Y. 2019. Energy consumption due to groundwater pumping for irrigation in the North China Plain. Science of the Total Environment. 669:1033-1042. DOI: 10.1016/j.scitotenv.2019.03.179

Guzman-Rojo, D.P., **Bautista, E.**, Gonzalez-Trinidad, J., **Bronson, K.F.** 2018. Variability of furrow infiltration and estimated infiltration parameters in a macroporous soil. Journal of Irrigation and Drainage Engineering. 145(2):04018041. DOI: 10.1061/(ASCE) IR.1943-4774.0001366. (PDF)

French, A.N., Hunsaker, D.J., Bounoua, L., Karnieli, A., **Luckett, W.E., Strand, R.** 2018. Remote sensing of evapotranspiration over the central Arizona irrigation and drainage district, USA Agronomy, 8: 278 (PDF)

Hunsaker, D.J., Elshikha, D.M., Bronson, K.F. 2019. High guayule rubber production with subsurface drip irrigation in the US desert Southwest. Agricultural Water Management, 220:1-12. (PDF)

Kothari, K., Ale, S., Bordovsky, J.P., **Thorp, K.R.**, Porter, D.O., Munster, C.L. 2019. Simulation of efficient irrigation management strategies for grain sorghum production in the Texas High Plains. Agricultural and Forest Meteorology. 170:49-62. DOI: 10.1016/j.agsy.2018.12.011

Pauli, D., Ziegler, G.R., Ren, M., Jenks, M.A., **Hunsaker, D.J.**, Zhang, M., Baxter, I.R., Gore, M.A. 2018. Multivariate analysis of the cotton seed ionome reveals a shared genetic architecture. G3, Genes/Genomes/Genetics. 8: 1147-1160. (PDF)

Thorp, K.R., Thompson, A.L., Harders, S.J., **French, A.N.**, Ward, R.W. 2018. High-throughput phenotyping of crop water use efficiency via multispectral drone imagery and a daily soil water balance model. Remote Sensing. 10:1682. (PDF)

Plant Science

Abdel-Haleem, H.A., Waltz, Q., **Leake, G.** 2019. Tolerance of transplanted guayule seedlings to post-emergence herbicides. Industrial Crops and Products. 133:292-294. (PDF)

Condorelli, G.E., Maccaferri, M., Newcomb, M., Andrade-Sanchez, P., **White, J.W.**, Sciara, G., Tuberosa, R., **French, A.N.** 2018. Comparative aerial- and ground-based high-throughput phenotyping for the genetic dissection of NDVI as a proxy for drought-adaptive traits in durum wheat. Frontiers in Plant Science. 9:893. (PDF)

Kimball, B., Boote, K., Hatfield, J.L., Ahuja, L.R., Stockle, C., Archontoulis, S., Caron, C., Basso, B., Bertuzzi, P., Constantin, J., Deryng, D., Dumont, B., Durand, J., Ewert, F., Gaiser, T., Gayler, S., Hoffmann, M.P., Jiang, Q., Kim, S., Lizaso, J., Moulin, S., Nednel, C., Parker, P., Palosuo, T., Priesack, E., Qi, Z., Srivastava, A., Tommaso, S., Tau, F., **Thorp, K.R.**, Timlin, D.J., Twine, T.E., Webber, H., Willaume, M., Williams, K. 2019. Simulation of maize evapotranspiration: An inter-comparison among 29 maize models. Agricultural and Forest Meteorology. 271:264-284. (PDF)

Luo, Z., Brock, J., **Dyer, J.M.**, Kutchan, T., Augustin, M., Scachtman, D., Ge, Y., Fahlgren, N., **Abdel-Haleem, H.A.** 2019. Genetic diversity and population structure of a *Camelina sativa* spring panel. Frontiers in Plant Science. 10:184. (PDF)

Luo, Z., Tomasi, P., Fahlgren, N., **Abdel-Haleem, H.,** 2019. Genome-wide association study (GWAS) of leaf cuticular wax components in Camelina sativa identifies genetic loci related to intracellular wax transport. BMC Plant Biology 19, 187. (PDF)

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Teresinski, H.J., Gidda, S.K., Nhuyen, T.N., Howard, M., Porter, B.K., Grimberg, N., Smith, M.D., Andrews, D.W., **Dyer, J.M.**, Mullen, R.T. 2018. An RK/ST C-terminal motif is required for targeting of OEP7.2 and a subset of other Arabidopsis tail-anchored proteins to the plastid outer envelope membrane. Plant and Cell Physiology. 60:516-537. DOI: 10.1093/pcp/pcy234

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Thompson, A.L., Conrad, A.V., Conley, M.M., Shrock, H., Taft, B., Miksch, C.L., Mills, T.V., Dyer, J.M. 2018. Professor: A motorized field-based phenotyping cart. HardwareX e00025 (PDF)

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Vanhercke, T., **Dyer, J.M.**, Mullen, R.T., Kilaru, A., Rahman, M.M., Petrie, J.R., Green, A.G., **Yurchenko, O.**, Singh, S.P. 2019. Metabolic engineering for enhanced oil in biomass. Progress in Lipid Research. 74:103-129. DOI: 10.1016/j.plipres.2019.02.002

Entomology and Plant Pathology

Boyle, N., Machtley, S.A., **Hagler, J.R.,** Pitts-Singer, T. 2018. Evaluation of the persistence of fluorescent and protein powders on adult blue orchard bees, *Osmia lignaria* (Hymenoptera: Megachilidae), for mark-capture studies. Apidologie. 49: 378-385. (PDF)

Boyle, N., *Tripodi, A.D.*, Machtley, S.A., Pitts-Singer, T.L., Strange, J.P., **Hagler, J.R.** 2018. A nonlethal method to examine non-*Apis* bees for mark-capture research. Journal of Insect Science. 18:10:1-6. (PDF)

Brent, C.S. 2018. Mating and social contact change egg production and longevity in adult females of the mirid *Lygus hesperus*. Entomologia Experimentalis et Applicata. 166:545-554. (PDF)

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