ALARC Highlights

Summer 2020

USDA-Agricultural Research Service

Arid-Land Agricultural Research Center

Maricopa, Arizona

We continue to pursue our mission to deliver scientific solutions to regional, national and global agricultural challenges. We hope that you and your families stay safe and healthy as we navigate these difficult times.

In this issue

Featured Accomplishment

Tracking water and salts to sustain Yuma agriculture

Yuma is one of the most important agricultural regions in the U.S., with annual food production exceeding $2 billion. Yuma lies in the southwestern-most corner of Arizona, bounded by California to the west and Sonora, Mexico to the south (Fig. 1). Most notable is its production of leafy greens—iceberg lettuce, romaine, spinach—where up to 90% of the North American supplies are provide by Yuma farms. This is achieved because growers increase their yields annually while maintaining nearly constant water use. Their systems are efficient and economically productive. However, the future of irrigated agriculture in Yuma is threatened by drought, supply shortages from the Colorado River, and competing water demands from urban areas.

Since 2016, scientists at ALARC in Maricopa have been engaged in collaborative research to help reduce these threats. Utilizing field, laboratory, and computational resources, the project mission is to establish current water needs and create tools to improve water management. Goals are to quantify how much water is used by every economically significant crop grown in Yuma, to develop tools to improve water use and salt management, and to establish practical ways to monitor water using remote sensing tools. Partners include hydrologists and agricultural engineers with the University of Arizona, the U.S. Bureau of Reclamation, Cotton, Inc., irrigation district managers, and private growers.

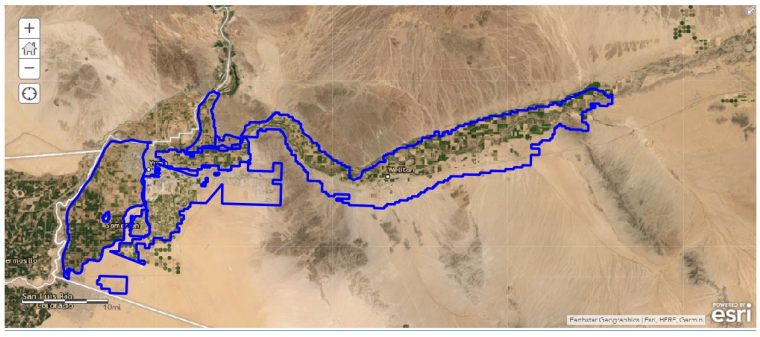


Figure 1. The Yuma agricultural region (32.7° N, 114.6° W) is depicted as green areas in the satellite image composite. It extends 100 km (62 miles) east-west, 35 km (22 miles) north-south, and is defined by the lower Colorado and Gila River drainage systems. It contains 6 Arizona and 1 California irrigation district (blue outlines)

Crop Water Use

A project priority has been to create an accurate accounting of current water requirements. Despite continuing improvements in farm irrigation practices, standard estimates of crop water requirements have not been updated for decades. Without having accurate values for crop water use under current conditions, meaningful planning for future years isn't possible.

For the last three years, crop water accounting has been done using a suite of meteorological instruments known as eddy covariance (ECV). These are well-established systems that observe plant transpiration and soil evaporation using high frequency meteorological observations. In contrast to other techniques- examples include gravimetric sampling, weighing lysimeters, and soil moisture probes — ECV data are advantageous because of their relative portability, fine time resolution, and field-wide sampling footprint. Each ECV consists of three main components: 1) environmental sensors, 2) data loggers to store the observations, and 3) station infrastructure such as tripods, solar panels, and communication modems (Fig. 2). ECV's are installed close-in-time to planting and with a few exceptions remain in the

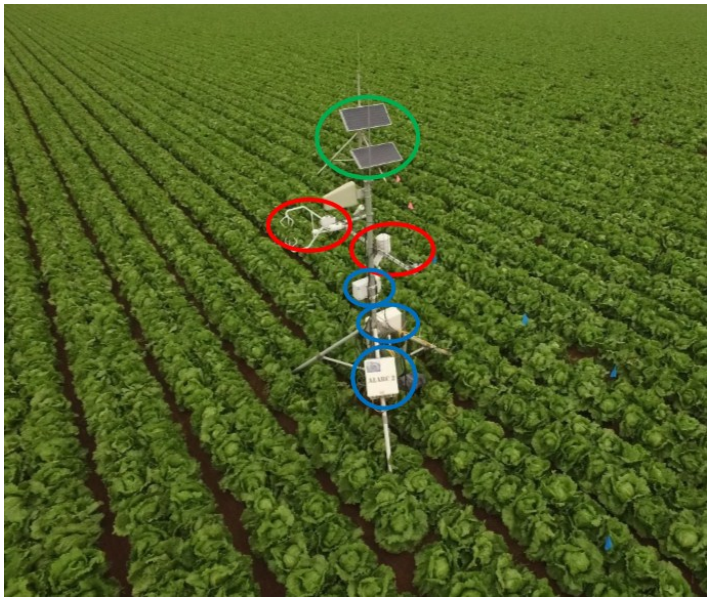


Figure 2. Eddy covariance station deployed in a two-row lettuce field at Yuma. Components include meteorological sensors (red), data controller and loggers (blue), and power supply (green).

field until harvest. The ECV collects wind speed, air temperature, and humidity data at high rates, 20 Hz, then cross-correlates them to obtain net vertical transport of heat and water vapor. Summing the measured water fluxes over 24 hours returns total daily evapotranspiration (ET). Summing over the growing season provides an estimate of total crop water use.

Using a collection of 8 ECV stations, the team has visited over 45 Yuma sites to determine water use for crops such as lettuce, spinach, durum wheat, Sudan grass, and cotton. An example ECV data set for a durum wheat site (Fig. 3), shows the evolution of crop water use from planting to harvest.

Note the comparison between ECV-observed ET (blue) and reference ET (ET0, red): early and late-season water values are less than weather station derivations. This means that consumptive use of water is much less than might be estimated from standardized methods. Charted against day of year, daily ET (mm) is initially low, ~1 mm/day, and dominantly evaporation from bare soil. When the wheat crop is mature, daily ET is maximal, ~8 mm/day, and dominantly transpiration. With onset of senescence, all sources of ET rapidly decline to a background level of 1 mm/day. Not easily resolved with other methods, ECV data detects short duration high-evaporation events following irrigation and rainfall. When summed across the season, daily ET observations are transformed to cumulative water use. Seasonal amounts vary widely by crop (durum wheat 23.7", lettuce 9.7", cotton 33.9", spinach 4.1", Sudan grass 25.7"). Using applied irrigation volumes as provided by growers, irrigation efficiencies at Yuma are high, on the order of 90%.

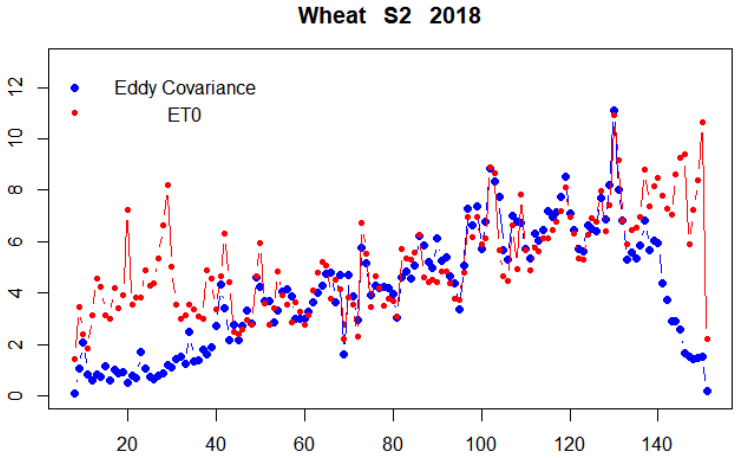


Figure 3. Daily ET data over durum wheat obtained from ECV observations (blue) compared with weather station based reference evapotranspiration (ET0, red).

Salinity Management

A critical question related to crop water requirements is how much additional water is needed to maintain low soil salinity levels. This is especially important if irrigation efficiencies are high. In arid environments irrigated lands accumulate salts and can't be sustained without a leaching fraction to push salts below rooting depths. With ample water supplies, rules of thumb suggest about 1/5 of crop water requirements be applied to maintain sustainable soil salt concentrations. Supplies, however, are not ample and accurate accounting of salt inputs and outputs are needed.

By collecting wet soil extracts and electrical conductivity surveys at different parts of the growing season, research has begun to quantify salinity fluxes. Using the common lettuce/wheat rotation as a test framework, the team found that salt levels were primarily maintained by pre-lettuce season irrigations and not by follow-on wheat planting. As illustrated in Figure 4, tracking soil conductivity levels – a proxy for salinity- through time shows an annual cycle. Pre-irrigation reduces salinity about 0.5 dS/m, irrigation of lettuce increases levels ~1.0 dS/m, and irrigation of wheat

either maintains or increases levels still further (Fig. 4, left). If these findings hold with further experiments, future water and salt management strategies will have to consider the cost and benefits of crops grown outside of lettuce and whether or not there are ways to reduce salt loading events at all times of the year. Some loading events are effectively managed by moving salts laterally instead of downward (Fig. 4, right). Experiments in 2017 tracked salt movement between lettuce beds and furrow. Initial irrigations are by

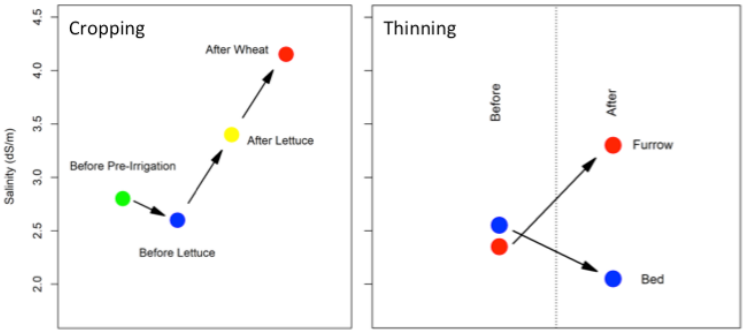


Figure 4. Salinity mapping at Yuma. Irrigation prior to lettuce reduce salt loads, while other events increase them (left). Within the bed/furrow field structure for lettuce, flood irrigation moves salts laterally away from sensitive lettuce roots (right).

solid set sprinklers—a practice needed to create a cool micro -climate needed for lettuce emergence, but an event that is salt loading. However tracking of shallow salts showed than subsequent irrigation was able to flush salts laterally from beds into furrows without providing an additional leaching fraction.

Mapping Crop Water Use

Using data from the ECV studies, water amounts applicable for current practice can be used as a basic farm-level planning tool. But further improvements are possible. A potentially transformative way to help Yuma growers would be to provide maps of crop, water, and soil of their fields nearly daily. It isn't known yet how transformative or widely

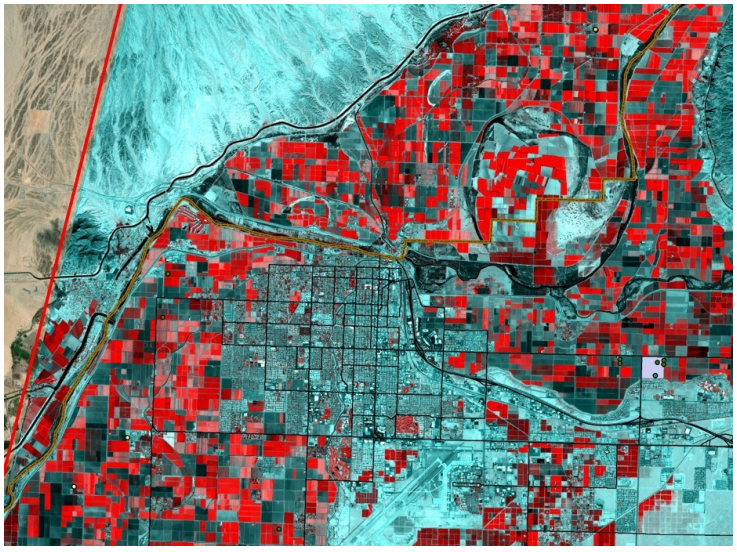


Figure 5. False-color 2020 imagery of Yuma crops from the Venus satellite. Red colors indicate dense, chlorophyll rich vegetation while blue colors indicate bare soil and non-vegetated surfaces.

used these maps would be, but their availability could enable irrigation and salt management programs accurate to a few percentage points. That would mean that field-specific irrigation and and salt mangement plans could be updated in near real time.

The maps would use satellite-based remote sensing image data. Until recently, the satellite data were too infrequent, delayed, or too coarse in resolution to be useful at field scales. Those limitations are now disappearing: in the past few years, images from Landsat, Sentinel 2, and Venus are available almost every other day, some with resolution as fine as 5 m. An example for Yuma is shown in Fig. 5, which discriminates crop at different growth stages and urban areas. Using the spectral information from satellites, crop

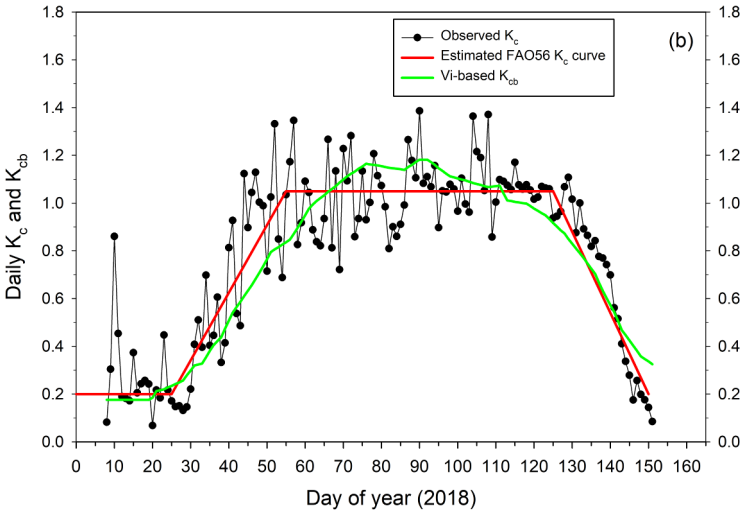


Figure 6. Daily crop coefficients over durum wheat in Yuma, 2018. ECV observations (black) track the rapidly changing day-to-day changes, while remote sensing based coefficients provide a time-averaged chart (green). Following standard FAO-56 procedures result in the trapezoidal shaped crop coefficient path (red).

coefficients that represent actual conditions can guide irrigation decisions. Using data from ECV data to validate results, the team has created remotely sensed crop coefficients (Fig. 6). These charts summarize plant growth and make possible accurate, daily-to-seasonal water use monitoring and forecasting.

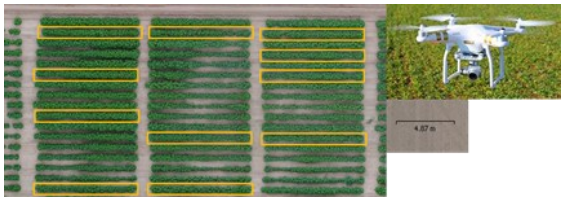
(Contact: Andrew.French@usda.gov)

Terra-Ref, the world's largest field scanner was used this winter in collaborative work with The University of Arizona. Using >140 lines of lettuce, the goal was to dissect the genetic basis of water stress by remotely measuring multiple plant traits.

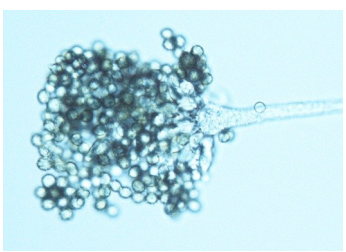
Other Accomplishments

Characterizing genetic diversity of a spring *Camelina sativa* diversity panel. *Camelina sativa*, a crop originating from southeastern Europe and southwestern Asia, is showing renewed public interest. Camelina has high potential for use as a biofuel crop in semi-arid sustainable agricultural systems. To facilitate faster genetic enhancement and efficient breeding progress in camelina, we collaborated with scientists at the University of Nebraska, Lincoln, and the Donald Danforth Plant Science Center in St. Louis, Missouri, to use high-throughput genotyping-by-sequencing technology for exploring genetic diversity and adaptation among accessions. The camelina panel showed high levels of genetic diversity that could serve as the basis for developing new cultivars with higher yields higher oil production and better tolerance to abiotic stress in diverse environments. **Contact:** Hussein.Abdel-Haleem@usda.gov

High-throughput phenotyping methods determine water use efficiency in cotton. Plant water use efficiency (WUE) is an important trait for crops grown under dry-land or limited irrigation production. WUE is a difficult trait to quantify, requiring information tools for quantifying how much water is used by the crop, and therefore, has rarely been applied to breeding trials. We developed an approach to rapidly quantify crop water use for a large number of cotton breeding plots. The approach provided new and improved data that permitted selection of varieties that were more drought tolerant and used water more efficiently. This approach provides a valuable new tool for plant breeders and researchers aiming to use information technologies to quantify plant WUE. **Contact:** Alison.Thompson@usda.gov



Molecular methods to ID aflatoxin producing fungi. *Aspergillus flavus*, the principal cause of aflatoxin contamination of food and feed, is globally distributed. This fungus is common in the agroecosystem, but tools for strain-specific identification have been imprecise or labor-intensive. We have assembled a global collection of over 40,000 *A. flavus* isolates and developed a SSR (simple sequence repeat) based method to characterize isolates at 17 loci with exceptional precision. Screening of the first 29,000 isolates has revealed high diversity, with > 13,000 unique haplotypes discovered to date. This methodology and the resulting dataset are being shared with other researchers to document the geographic structure of the *A. flavus* population and explore the interactions between environment and genotype. **Contact:** Ken.Callicott@usda.gov



Novel mechanism of pink bollworm resistance to Bt crops. Transgenic crops engineered to produce insecticidal proteins from the bacterium *Bacillus thuringiensis* (Bt) provide many benefits including pest suppression, increased yields and farmer profits, reduced conventional insecticide use, decreased harm to non-target species, and enhanced biological control. However, pest resistance to Bt crops decreases such benefits. Pink bollworm is a global pest of cotton and resistance to the toxins of Bt cotton involve mutations and/or cellular trafficking of a cadherin receptor protein thought to prevent toxin binding to the insect midgut. We collaborated with researchers from the University of Arizona, to show that the down-regulation of cadherin transcript and protein is responsible for loss of the available receptor, thus showing the adaptability of pink bollworm to evolve resistance to Bt toxins. Results are valuable for scientists concerned with understanding the mechanisms of resistance, for private industry developing new commercial strategies to target pests, and for government authorities responsible for regulating transgenic crops. **Contact:** Jeff.Fabrick@usda.gov

Flight mill technology for the study of insect flight behavior. Dispersal is a key component in the ecology and dynamics of insect populations, yet it remains one of the most difficult processes to study in the field. Many researchers have looked to laboratory methods for investigating the factors that influence an insect's ability to move within its environment. We reviewed and synthesized the global literature on the development, use, and data interpretation of insect flight mills for the study of flight behavior. The study provided details on the construction and operation of a flight mill we have developed, including access to websites and videos [Link]. The technology has been used by numerous scientists studying a wide range of insect pests and is of substantial value to those interested in applying flight mills for the study of insect dispersal. **Contact:** Steve.Naranjo@usda.gov

Tracking the dispersal of arthropod predators and parasitoids. Knowledge of arthropod predator and insect parasitoid dispersal patterns is critical for effective biological control of grape pests. We collaborated with scientists at the University of California, Riverside to develop a novel method to track arthropod movement in a vineyard containing a buckwheat cover crop. Arthropods were marked directly in the buckwheat plots using a "triple mark" solution containing yellow dye, milk protein, and egg protein. The abundance of

marked and unmarked natural enemies was recorded at a gradient of distances from the treated buckwheat plots into the vineyard. Results revealed that buckwheat refuges planted every sixth or tenth row within the vineyard could increase the biological control services on key grape pests. **Contact:** James.Hagler@usda.gov

Satellite remote sensing quantifies irrigated crop water use in Arizona. Persistent drought and declared water shortages are threatening the sustainability of farms in Central Arizona. Known methods to conserve crop water resources, such as land leveling and use of pressurized irrigation, can be effective management tools; however, accurate water use amounts are lacking, meaning that policy planning and on-farm decision making are difficult. We used satellite remote sensing images and water balance models to quantify water use by cotton, wheat, and alfalfa in the Central Arizona Irrigation District. Results provide important tools and baseline data for farmers and district managers to assess their current and future irrigation needs. **Contact:** Andrew.French@usda.gov

Development of WinSRFR 5 completed. Surface irrigation systems still account for nearly 40% of the irrigated land in the U.S. Many of those systems are inadequately designed, and as a result, produce large water losses. Performance of those systems can be improved with the assistance of hydraulic analysis tools. We completed the development of Version 5 of WinSRFR, software for the analysis of surface irrigation systems [Link]. The software is being used primarily by National Resources Conservation Service (NRCS). Key software enhancements include the addition of procedures for modeling furrow infiltration based on physical principles, a module for modeling fertigation events (solute transport), new design options for furrows, and a new module for the estimation of infiltration and hydraulic resistance parameters (inverse solution). Simulation and field studies have validated the usefulness of this infiltration modeling approach. **Contact:** Eduardo.Bautista@usda.gov

Aeration of irrigation water reduces pharmaceutical uptake in fresh produce. Water scarcity has led to the increasing use of treated municipal wastewater containing low levels of pharmaceuticals for irrigation. We showed that increased aeration of irrigation water using an air injection system prior to sub-surface drip irrigation can reduce the fate and uptake of some pharmaceuticals into food crops. Air injection was shown to reduce the concentration of three pharmaceuticals (caffeine, carbamazepine, and gemfibrozil) in the soil and leachate. Uptake of caffeine and gemfibrozil into lettuce was lower withe air injection, but carbamazepine uptake was greater. Air injection also changed the soil microbial community. The approach may be a useful point of use treatment technology to reduce the environmental availability of pharmaceuticals, benefiting producers and consumers of leafy green vegetables. **Contact:** Clinton.Williams@usda.gov

Current Grant Awards (*new)

*Elucidating the cellular machinery for lipid storage in plants, DOE-BES (PI Kent Chapman, CO-PIs **John Dyer**, Robert Mullen) 2019-2022

*Applying proximal sensing to enhance upland cotton yield trials, Cotton Incorporated (PI **Alison Thompson**) 2020

*Molecular genetic and proximal sensing analyses of abiotic stress response and oil production, USDA-ARS Innovation Fund (PI **James Kim**, Co-PI Hussein **Hussein Abdel-Haleem**) 2019

*Quantifying life-stage predation events on *Lygus hesperus* using a pinpoint immunological procedure, Arizona Cotton Growers Association, Arizona Cotton Research and Protection Council (PI **James Hagler**) 2020

*Gene silencing/editing methods in *Lygus hesperus*: Further optimization and elucidation, Cotton Incorporated (PI **Colin Brent**, Co-PIs **Jeff Fabrick, Joe Hull**) 2020

*Population genomics of Bt resistance in *Helicoverpa zea*, USDA-NIFA, (PI Bruce Tabashnik, Co-PIs Yves Carriere, Luciano Matzkin, **Jeff Fabrick**) 2020-2022.

*Improving insect management strategies in Arizona Cotton, Arizona Cotton Growers Association. (PI Peter Ellsworth, CO-PI **Steve Naranjo**) 2020

* Selectivity of cotton insecticides drive ecotoxicological gains and improve Arizona cotton IPM, Cotton Incorporated. (PI Peter Ellsworth, CO-PIs **Steve Naranjo**, Al Fournier) 2020

* Artificial intelligence for sustainable water, nutrient, salinity, and pest management in the Western US, USDA-NIFA (PI E. Scudiero, CO-PIs H. Ajami, R. Anderson, K. Bali, M. Cahn, N. Chaney, K. Chief, A. Eldawy, **Andrew French**, R. Khosla, M. McGiffen, C. Nugent, E. Papalexakis, A. Putman, M. Rivera, C. Sanchez, K. Schwabe, T. Skaggs, G. Vellidis) 2020-2026

*High-throughput phenotyping using portable LIDAR, Cotton Incorporated (PI **Andy French** with Co-PIs Michael Gore, **Alison Thompson**) 2020

*Applications for nitrogen fertilizer management for irrigated cotton, Cotton Incorporated (PI **Kevin Bronson**) 2020

*Evaluation and improvement of crop simulation models to meet the data needs of modern cotton production systems, Cotton Incorporated (PI **Kelly Thorp**) 2020

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 K. Ogden, Co-PIs D. Ray, P. Waller, R. Maier, I. Meghan Downes, W. McCloskey, T. Teegerstrom, O. Idowu, P. Gutierrez, K. Grover, F. Holguin, C. Brewer, S. Angadi, **Hussein Abdel-Haleem**, C. McMahan, D. Dierig, A. Landis, J.Quinn, X. Bai, K. 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) 2016-2020

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

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

Understanding the potential for resistance and biological control impacts of thrips and plant bug active Bt deployment, USDA-NIFA, Biotechnology Risk Assessment Grant Program (PI Anders Huseth, Co-PIs G. Kennedy, P. Ellsworth, **Steve Naranjo**) 2018-2021

Molecular and environmental factors controlling aflatoxin reduction by non-toxigenic *Aspergillus* strains, Arizona Cotton Research and Protection Council (PI **Steve Naranjo**, Co-PI **Ken Callicott**) 2018-2023

Prevention of aflatoxin contamination of maize in pakistan with biological control based on atoxigenic strains of *Aspergillus flavus*, Ingredion [Pakistan] (PI **Steve Naranjo**, Co-PI **Ken Callicott**) 2018-2022

Use of atoxigenic strains of *A. flavus* to manage aflatoxin in Texas corn, Texas Corn Growers Association (PI **Steve Naranjo**, Co-PI **Ken Callicott**) 2016-2020

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**) 2016-2021

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

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) 2017-2021

The nexus of agricultural & urban trade-offs: Interdisciplinary education & research to create emerging opportunities in urban agriculture, USDA-NIFA, (PI Rebecca Muenich, CO-PIs Otakuye Conroy-Ben, Peter Condon, **Clinton Williams**) 2018-2021

Occurrence and treatment of unregulated organic micropollutants in the San Jaun River, US Bureau of Reclamation (PI Anthony Kennedy, Co-PI **Clinton Williams**) 2019-2021.

Monitoring evapotranspiration, crop growth and nutrient stress over irrigated crops in central Arizona, NASA (PI **Andrew French**, Co-PIs **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 J. McKay, CO-PIs P. Antin, R. Bartels, T. Borch, P. Andrade Sanchez, F. Cotrufo, **Andrew French**, M. Ottman, S. Palickara, K. Paustian, P. Schnable, C. Topp, C. Turner, M. Wallenstein, J. Yu) 2017-2020.

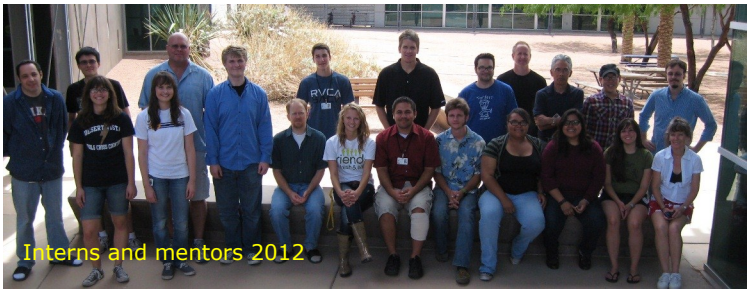
Recent Professional Awards and Recognition

Mr. William Velez was honored as the **2020 ARS Office Professional of the Year** for the entire agency. This distinction recognizes his dedicated administrative service to the agency's research mission to deliver scientific solutions to national and global agricultural challenges. William was to be honored in an award ceremony in April at ARS Headquarters in Beltsville, Maryland but that was postponed due to the COVID19 pandemic.

Dr. James Hagler received the **2019 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 St. Louis, MO in November 2019.

Dr. Kevin Bronson was the recipient of the **2020 Outstanding Career Research Award in Cotton Agronomy**, presented by the National Cotton Council. He was recognized for his internationally known research in nitrogen soil fertility and management, nitrogen cycling, fertigation, nitrogen by irrigation management, proximal nitrogen sensing, and precision agriculture. Dr. Bronson was honored at the Beltwide Cotton Conferences in January in Austin, Texas. [Link] [Link]

ALARC received the 2020 **ARS-Pacific West Area Diversity and Outreach Award /EEO Award** for their long time involvement in programs to provide outstanding mentoring to the next generation of STEM scientists. Since 2012 we have been involved in partnerships with faculty from South Mountain Community College (Advancing an Undergraduate Bioscience Engagement Track, 2012-2015) and Central Arizona Community College (Project Puente, 2015-present) to provide under-represented high school and undergraduate students with hands-on science experiences. In 2017 ALARC was honored with the Innovation Award in Business by the COX Connect2STEM program for this effort [Link]


Interns and mentors 2012

Employee Engagement

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

ALARC held its 5th 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, Scott Machtley and Miles Casey for helping with the theme and Robert Lamorte, Mike Roybal and Devon Large for printing the posters.*


1st Place: Matt Hagler

2nd Place: Aaron Szczepanek


3rd Place: Damien Seay

Brenda Singleton, Mike Roybal, Colin Brent, John Dyer, Kevin Bronson and Steve Naranjo organized three **employee engagement programs** this past year. Topics included conversational competence, resolving workplace conflicts, improving teams through effective communication, the importance of listening for effective communication, personality assessment and boundaries in the work place. Events used a combination of videos, presentations and hands-on/group activities. All events were followed with pizza or sub sandwich lunches enabling further employee interactions.

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 Agency level.

For the third year, we planned to use **Administrative Professionals Day** in mid-April to celebrate and thank all ALARC employees. The event had to be postponed due to COVID-19 and the plan is for the RLs, CD and AO to host a Fourth of July BBQ if possible.

As part of the **Audio/Visual (AV) Brown Bag Seminar Series**, IT Specialist Robert LaMorte providing several training sessions on the use of OneDrive for accessing Microsoft programs remotely and accessing and storing data from multiple devices and locations. Another session led by Miles Casey focused on how to use PowerPoint for creating diagrams and figures.

In July ALARC held its annual '**Star Wars Appreciation Day'** by viewing battle droid, highlights from movies as well as a 'Clone Wars' episode. Some attendees wore Star Wars clothing and various themed deserts were also shared.

To celebrate **Earth Day** 2020, ALARC held a plastic upcycling contest to see what innovative ideas employees could design to extend the life of various plastics. With most employees teleworking we invited families to join the contest. The winners displayed real creativity with a showy bird feeder, an elegant hummingbird feeder a fun piece of yard art.


1st Place
Connie
Graham


2nd Place
Sharette
Rockholt


3rd Place
Adrienne &
Wesley Thorp

ALARC IN THE NEWS

Drones for irrigation management. An ALARC scientist shows how drones are being used to scan and map crop conditions and help growers determine how to most efficiently manage irrigation water for optimal yields. From Cronkite News at Arizona State University and the Maricopa Monitor [Link] [Link]

ALARC recognized for research accomplishments. ALARC scientists are working on a number of fronts to help agriculture to be more productive and economical. Highlighted is the Center's recent work on biological control of fungi that produce aflatoxin, a potent human and animal toxin that infests many desert crops, and the development of alternative crops that reduce water use and provide growers with options. From the Maricopa Monitor [Link]

Tracking water use and salinity in Yuma. ALARC scientist are cooperating with University of Arizona, U.S. Bureau of Reclamation, Cotton Inc., irrigation district managers, and private growers to measure and improve water use efficiency and salinity management in a variety of Yuma crops with sophisticated proximal and remote sensing technology. From Western Farm Press (see Featured Accomplishment) [Link]

Unlocking the secrets of plant energy. In collaboration with scientists at the University of North Texas and the University of Guelph, ALARC scientists are gaining a better understanding of how to improve the storage and utilization of lipids in plants as a source of renewable bioenergy. From University of North Texas News [Link]

Secretary Perdue visits Arizona. As part of the 5th Annual Arizona Agribusiness Roundtable, U.S. Secretary of Agriculture Sonny Perdue sat down with Arizona Department of Agriculture Mark Killian to discuss trade and other agricultural issues affecting Arizona. From Western Farm Press [Link]

Farm Science Day 2020. After the Federal Government shutdown in 2018/2019 scuttled Farm Science Day 2019, ALARC was anxious to host their annual outreach event in 2020. The late February 2020 date was postponed due to rain and the COVID-19 pandemic eventually forced us to cancel our rain-date in mid March. We look forward to a big comeback in 2021! The event focuses on educating the local community about agriculture and the science behind it in family friendly environment. From the Maricopa Monitor [Link] [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. Spring seminars were cut short this year due to the COVID-19 pandemic. If you are interested in getting advance notice of seminar speakers and topics, please email steve.naranjo@usda.gov.

RECENT EVENTS AND OUTREACH

June 2019, ALARC hosted the annual Summer Ag Institute (SAI) group, 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, 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 2019, ALARC hosted its semi-annual Stakeholder Meeting. 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 biological control of aflatoxin producing fungi in crops. 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.

June 2019, The ALARC EEO Committee celebrated Lesbian, Gay, Bisexual and Transgender (LGBT) Pride Month by hosting an event in which all location personnel were invited to view several TED talks on how we see ourselves and how we see each other. Refreshments were provided.

June-July 2019, ALARC scientists from all three units hosted a total of 8 students (science and IT) during the fourth 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 informal Intern Pizza Party as well as at a formal closing ceremony where interns displayed/presented their research posters, made oral presentations describing their internship experiences, and were recognized by Central Arizona College for their completion of the program. Students earned three college-level credits while engaged in a unique learning opportunity. ALARC scientists have been actively involved in training and mentoring under-represented students in programs since 2012.

July/December 2019, ALARC hosted visiting undergraduate Irrigation Engineering students from the Autonomous University of Chapingo, Texcoco, Mexico. The July group consisted of 24 students and faculty members. The December group consisted of 50 students and faculty members. *Drs. Eduardo Bautista, Diaa El-Shikha, Kelly Thorpe, Doug Hunsaker, Andrew French* and *Mr. Matt Conley* discussed ongoing research on surface irrigation modeling, guayule irrigation and management, site-specific irrigation, irrigation scheduling, remote sensing in irrigated agriculture, and precision 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 learn about our research programs.

October 2019, Educator Debbie Lenz and a group of 40 Academy Chemistry students from McClintock High School (Tempe, AZ) visited ALARC to learn about research currently being conducted on plant leaf wax and the roles it plays in drought tolerance. *Pernell Tomasi* showed students how mass spectrometry is used to identify and quantify leaf wax components from several important agricultural crops.

November 2019, ALARC hosted approximately 40 STEM (Science, Technology, Engineering and Math) students and instructors from Maricopa High School and Central Arizona College. Staff from the Water Management & Conservation, Plant Physiology & Genetics, and Pest Management & Biocontrol Research Units highlighted research including high-throughput phenotyping (HTP), remote sensing, advancements in irrigation, and molecular biology/genomics of insect pests. Students were also made aware of the Project Puente summer internship program at ALARC.



January 2020, ALARC broadcasted a live webinar commemorating the memory of the Holocaust and its victims. The broadcast was held at the United States Holocaust Memorial Museum, and featured the U.S. Ambassador to Sweden and two Holocaust survivors.

January 2020, ALARC hosted an open house for Arizona cotton growers and other stakeholders in partnership with Americot. The event provided the opportunity for growers and other stakeholders from national and state offices to interact with ALARC scientists and staff who presented research through scientific posters and interactive displays. Event was attended by about 60 stakeholders and approxi-



mately 30 staff and concluded with a catered barbeque lunch and door prizes sponsored by Americot. This event also served as our winter stakeholder meeting.

February 2020, The ALARC EEO/Diversity Committee hosted an event as part of the Departmental Special Emphasis Program (SEP) to celebrate National African American History Month. *Joseph Garrett* provided a presentation entitled "African Americans and the Vote". Attendees had fun with a cross-word puzzle activity and enjoyed a BBQ lunch. In addition to this event, we created an "EEO Engagement Center" to showcase past and present African American entrepreneurs for the month of February. The display provides examples of how many African Americans found success in antebellum America by harnessing their talents and creating profitable businesses -- ultimately paving the way for future generations to come.

February 2020. ALARC's annual outreach event, Farm Science Day, was not held in 2020. Due to late February rain we postponed the event and the COVID-19 pandemic forced us to cancel the rain date in mid March. 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 2021.

Dr. Eduardo Bautista explains how computer simulation models can be used to help growers improve the efficiency of their surface irrigation systems during our Open House in January .

March 2020, The ALARC EEO/Diversity Committee hosted a virtual celebration of Women's History Month featuring several videos including Top 10 First for Women in History, The Historic Woman's Suffrage March on Washington, and Tarana Burke Me Too is a Movement Not a Moment. Women's History Month has its origins going back to 1911 with International Women's Day, which took place on March 8th. This day was officially commemorated by the United Nations in 1975. The U.S. began celebration of the Women's History Month in the 1970's but it did not become an officially declared event until later in the 1980s. Special thanks to *Alison Thompson, Matt Herritt, Mike Roybal, Damien Seay, Brenda Singleton and Melissa Stefanek* for putting the event together.

April 2020. ALARC employees celebrated **Earth Day** virtually this year with a series of videos about the 50 year anniversary (Earth Day 1970 – 2020: 50th Anniversary| Time Will Tell), an engaging story of three plastic water bottles (What really happens to the plastic you throw away), and an inspiring TED talk from climate activist Greta Thunberg (The disarming case to act right now on climate change). Videos were accompanied by a brief written history of Earth Day. Special thanks to *Alison Thompson* for putting the program together.

May 2020, The ALARC EEO Committee hosted a virtual observance of Asian and Pacific Islander Heritage Month. *Kevin Bronson* gave a presentation on **The Philippines,** a Southeast Asian country of 7000 islands, whose history intersects with American history. He spoke about the history, geography, agriculture, and the people of the Philippines. He also shared slides from his family's recent 4-week vacation in the Philippines.

Recent Pubications

Plant Science

Abdel-Haleem, H., Luo, Z., Ray, D. 2019. Genetic improvement of guayule (*Parthenium argentatum* A. Gray): An alternative rubber crop. pp. 151-178, In: Advances in Plant Breeding Strategies: Industrial and Food Crops, J. Al-Khayri, S. Jain, D. Johnson (eds.). Springer, Dordrecht-Heidelberg-London-New York. (PDF) https://doi.org/10.1007/978-3-030-23265-8_6.

Allen, L.H., **Kimball, B.A**., Bunce, J.A., Toshimoto, M., Harazono, Y., Baker, J.T., Boote, K.J., **White, J.W.** 2020. Fluctuations of CO2 in Free-Air CO2 Enrichment (FACE) depress plant photosynthesis, growth, and yield. Agricultural and Forest Meteorology. 284: 107899. (PDF)

Boehm Jr., J., **Abdel-Haleem, H.A.**, Schapaugh Jr., W., Rainey, K., Pantalone, V.R., Shannon, G., Klein, J., Carter Jr, T.E., Cardinal, A.J., Shipe, E.R., Gillen, A.M., Chen, P., Smith, J.R., Weaver, D.B., Boerma, R., Li, Z. 2019. Genetic improvement of US soybean in maturity groups V, VI, and VII. Crop Science. 59: 1838-1852. https://doi.org/10.2135/cropsci2018.10.0627

Chapman, K.D., Aziz, M., **Dyer, J.M.**, Mullen, R.T. 2019. Mechanisms of lipid droplet biogenesis. Biochemical Journal. 476: 1929-1942. https://doi.org/10.1042/BCJ20180021

Esnay, N., **Dyer, J.M**., Mullen, R.T., Chapman, K.D. 2020. Lipid droplet-peroxisome connections in plants. Contact. 3: 1-14. (PDF)

Gazave, E., **Tassone, E.E.**, Baswggio, M., Cyder, M., Byrel, K., Oblath, E.A., Lueschow, S.R., Poss, D.J., Hardy, C.D., Wingerson, M., James, D.B., **Abdel-Haleem, H.A.**, Grant, D.M., Hatfield, J.L., Isbell, T., Vigil, M.F., **Dyer, J.M.**, Jenks, M.A., Brown, J., Gore, M.A., Pauli, D. 2020. Genome-wide association study identifies acyl-lipid metabolism candidate genes involved in the genetic control of natural variation for seed fatty acid traits in *Brassica napus* L.. Industrial Crops and Products. 145: 112080. https://doi.org/10.1016/j.indcrop.2019.112080.

Ischebeck, T., Mullen, R.T., **Dyer, J.M.**, Chapman, K.D. 2020. Lipid droplets in plants and algae: distribution, formation, turnover and function. Seminars in Cell and Developmental Biology, https://doi.org/10.1016/j.semcdb.2020.02.014

Kaler, A., **Abdel-Haleem, H.A.**, Fritschi, F.B., Gillman, J.D., Ray, J.D., Smith, J.R., Purcell, L.C. 2020. Genome-wide association mapping of dark green color index using a diverse panel of soybean accessions. Scientific Reports. 10: 5166. (PDF)

Kim, J.Y. 2020. Roadmap to high throughput phenotyping for plant breeding. Journal of Biosystems Engineering. 45: 43-55. (PDF)

Lin, Y., Chen, G., Mietkiewska, E., Song, Z., Caldo, K.P., Singer, S.D., **Dyer, J.M.**, Smith, M., Mckeon, T.A., Weselake, R.J. 2019. Castor patatin-like phospholipase A IIIß facilitates removal of hydroxy fatty acids from phosphatidylcholine in transgenic Arabidopsis seeds. Plant Molecular Biology. 101: 521-536. https://doi.org/10.1007/s11103-019-00915-w.

Luo, Z., **Thorp, K.R.**, **Abdel-Haleem, H.A.** 2019. A high-throughput quantification of resin and rubber contents in *Parthenium argentatum* using near-infrared (NIR) spectroscopy. Plant Methods. 15: 154. (PDF)

Luo, Z., **Abdel-Haleem, H.A.** 2019. Phenotypic diversity of USDA guayule germplasm collection grown under different irrigation conditions. Industrial Crops and Products. 142: 111867. (PDF)

Price, A.M., Doner, N., Gidda, S.K., Puri, V., James, C., Schami, A., **Yurchenko, O.**, Mullen, R.T., **Dyer, J.M.**, Chapman, K.D. 2019. Mouse Fat-Specific Protein 27 (FSP27) expressed in plant cells localizes to lipid droplets and promotes lipid droplet accumulation and fusion. Biochimie. 169: 41-53. https://doi.org/10.1016/j.biochi.2019.08.002.

Sturtevant, D., Lu, S., Zhou, Z., Shen, Y., Wang, S., Song, J., Zhong, J., Burks, D.J., Yang, A., Yang, Q., Cannon, A.E., Herrfurth, C., Feussner, I., Borisjuk, L., Munz, E., Verbeck, G.F., Wang, X., Azad, R.K., **Singleton, B.B.**, **Dyer, J.M.**, Chen, L., Chapman, K.D., Guo, L. 2020. The genome of jojoba (*Simmondsia chinensis*): A taxonomically isolated species that directs wax ester accumulation in its seeds. Science Advances. 6: eaay3240. (PDF)

Matt Conley with the Avenger high throughput phenotyping platform, our workhorse for crop improvement research.

Entomology and Plant Pathology

Barros, L.S., Yamamoto, P.T., **Merten, P., Naranjo, S.E.** 2020. Sublethal effects of diamide insecticides on development and flight performance of *Chloridea virescens* (Lepidoptera: Noctuidae): Implications for Bt soybean refuge area management. Insects 11, 269. (PDF)

Batz, Z.A., **Brent, C.S.**, Marias, M.R., Sugijanto, J., Armbruster, P.A. 2019. Juvenile hormone III but not 20-hydroxyecdysone regulates the embryonic diapause of *Aedes albopictus*. Frontiers in Physiology 10: 1352. (PDF)

Brent, C.S., **Spurgeon, D.W.** 2019. Reproductive development of *Lygus hesperus* (Hemiptera: Miridae) adults under constant and variable temperatures. Journal of Insect Science. 19(3): 24:1-6. (PDF)

Carriere, Y., Yelich, A.J., Degain, B., Harpold, V.S., Unnithan, G.C., Kim, J.H., **Mathew, L.G.**, Head, G.P., Rathore, K.S., **Fabrick, J.A.**, Tabashnik, B.E. 2019. Gossypol in cottonseed increases the fitness cost of resistance to Bt cotton in pink bollworm. Crop Protection. 126: 104914. https://doi.org/10.1016/j.cropro.2019.104914.

Christie, A.E., **Hull, J.J.** 2019. What can transcriptomics reveal about the phylogenetic/structural conservation, tissue localization, and possible functions of CNMamide peptides in decapod crustaceans? General and Comparative Endocrinology 282:113217. https://doi.org/10.1016/j.ygcen.2019.113217

Christie, A.E., **Hull, J.J.,** Dickinson, P.S. 2020. Assessment and comparison of putative amine receptor complement/diversity in the brain and eyestalk ganglia of the lobster, *Homarus americanus*. Invertebrate Neuroscience 20:1–14. https://doi.org/10.1007/s10158-020-0239-5

Christie, A.E., **Hull, J.J.,** Dickinson, P.S. 2020. In silico analyses suggest the cardiac ganglion of the lobster, *Homarus americanus*, contains a diverse array of putative innexin/innexin-like proteins, including both known and novel members of this protein family. Invertebrate Neuroscience 1–11. http://doi.org/10.1007/s10158-020-0238-6

Fabrick, J.A., **Mathew, L.G.**, **Leroy, D.M.**, **Hull, J.J.**, Unnithan, G.C., Yelich, A.J., Carriere, Y., Li, X., Tabashnik, B.E. 2020. Reduced cadherin expression associated with resistance to Bt toxin Cry1Ac in pink bollworm. Pest Management Science. 76: 67-74. (PDF)

Hagler, J.R., Machtley, S. 2020. Refinement of the protein immunomarking technique for mark-capture research. Journal of Insect Science 20(2): 8. (PDF)

Hagler, J.R., Casey, M., Machtley, S. 2020. A procedure for pinpointing cannibalism, intraguild predation, and life stage-specific feeding events. Biocontrol https://doi.org/10.1007/s10526-020-10005-2 (PDF)

Hagler, J.R., Mostafa, A.M. 2019. A gut analysis technique for identifying egg-specific predation events. Journal of Insect Science. 19(3): 1-7. (PDF)

Hagler, J.R., Nieto, D.J., **Machtley, S.A.**, Swezey, S.L. 2020. Predator demographics and dispersal in alfalfa trap-cropped strawberry. Entomologia Experimentalis et Applicata. 168: 53-58. (PDF)

Hull, J.J., Yang, Y.W., Miyasaki, K., **Brent, C.S.** 2020. TRPA1 modulates noxious odor responses in *Lygus hesperus*. Journal of Insect Physiology 122: 104038 (PDF)

Hull, J.J., Fónagy, A. 2019. Molecular basis of pheromonogenesis regulation in moths. pp. 151-202, In: Olfactory Concepts of Insect Control-Alternative to Insecticides, J.F. Picimbon (ed.). Springer, Chambridge, UK. (PDF)

Hull, J.J., Fónagy, A. 2020. A sexy moth model–the molecular basis of sex pheromone biosynthesis in the silkmoth *Bombyx mori*. pp. 111-150, In: Insect Sex Pheromone Research and Beyond, Y. Ishikawa (ed.). Springer, Singapore. (PDF)

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Montgomery, M., **Hagler, J.R.**, Vanderwoude, C., Lynch, A.J., Robinson, W.A. 2019. Laboratory evaluation of egg whites and milk as external biomarkers for *Wasmannia auropunctata* (Hymenoptera: Formicidae). Journal of Insect Science. 19(6)18: 1-5. (PDF)

Naranjo, S.E., Frisvold, G.B., Ellsworth, P.C. 2019. Economic value of arthropod biological control. pp. 49-85, In: The Economics of Integrated Pest Management for Insects, D. Onstad, P. Crain (eds.). Springer, Dordrecht-Heidelberg-London-New York. (PDF)

Naranjo, S.E., Hellmich, R.L., Romeis, J., Shelton, A., Velez, A. 2020. The role and use of genetically engineered insect-resistant crops in IPM systems. pp. 283-340, In: Integrated management of insect pests: Current and future developments, M. Kogan, E. Heinrichs (eds.). Burleigh Dodds Science Publishing, Cambridge, UK. (PDF)

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Ortega-Beltran, A., Moral, J., Picot, A., Puckett, R.D., **Cotty, P.J.**, Michaildes, T.J. 2019. Atoxigenic *Aspergillus flavus* isolates endemic to almond, fig, and pistachio orchards in California with potential to reduce aflatoxin contamination in these crops. Plant Disease. 103(5): 905-912. https://doi.org/10.1094/PDIS-08-18-1333-RE

Singh, P., **Cotty, P.J.** 2019. Characterization of *Aspergillis* from dried red chilies (*Capsicum* spp.): Insights into the etiology of aflatoxin contamination. International Journal of Food Microbiology. 289: 145-153. (PDF)

Singh, P., Orbach, M.J., **Cotty, P.J.** 2018. *Aspergillus texensis*: A novel aflatoxin producer with S morphology from the United States. Toxins. 10(12): 1-15. (PDF)

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Lygus bug, a key pest of cotton and other crop in the western U.S., on an alfalfa flower. Management of Lygus is a major thrust of research at the Center.

Spurgeon, D.W. 2020. Diapause response of *Lygus hesperus* (Hemiptera: Miridae) at different temperatures. Journal of Entomological Science. 55(1): 126-129. (PDF).

Wang, L., Wang, J., Ma, Y., Wan, P., Liu, K., Cong, S., Xiao, Y., Xu, D., Wu, K., **Fabrick, J.A.**, Li, X., Tabashnik, B.E. 2019. Transposon insertion causes cadherin mis-splicing and confers resistance to Bt cotton in pink bollworm from China. Scientific Reports. 9(1): 7479. (PDF)

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Anderson, R.G., **French, A.N.** 2019. Crop evapotranspiration. Agronomy. 9(10): 614. (PDF).

Bronson, K.F., Conley. M.M., Hunsaker, D.J., White, J.W., Thorp, K.R., French, A.N., Barnes, E.M. 2020. Which active optical sensor vegetation index is best for nitrogen assessment in irrigated cotton? Agronomy Journal. (PDF) https://doi.org/10.1002/agj2.20120

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Huang, J., Ridoutt, B.G., **Thorp, K.R.**, Wang, X., Lan, K., Liao, J., Tao, X., Wu, C., Huang, J., Chen, F., Scherer, L. 2019. Water-scarcity footprints and water productivities indicate unsustainable wheat production in China. Environmental Science and Technology. 224: 105744. https://doi.org/10.1016/j.agwat.2019.105744.

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Joshi, V.R., **Thorp, K.R**., Coulter, J.A., Johnson, G.A., Porter, P.M., Strock, J.S., Garcia Y Garcia, A. 2019. Improving site-specific maize yield estimation by integrating satellite multispectral data into a crop model. Agronomy. 9,719. (PDF)

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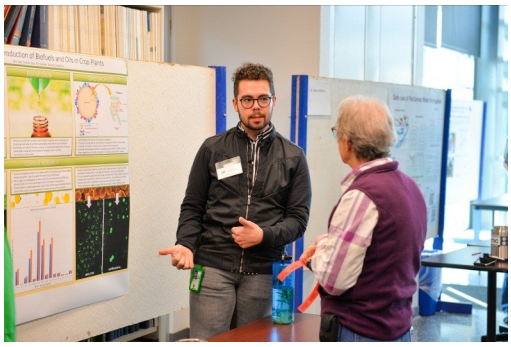

Left, Damien Seay discusses lipid storage for enhancement of biofuel crops and Scott Machtley talks about marking insects to study their intercrop movement with visitors to our Open House in January; Bill Luckett explains how global positioning systems (GPS) aid our proximal and remote sensing research for crop management and improvement to students during our November STEM event.

Photos: Paige Francis