

## ALARC Highlights – Spring 2015 Edition

*What's happening at the USDA-ARS, Arid-Land Agricultural Research Center, Maricopa, AZ*

### ***In this issue***

**Featured Accomplishment**

**Other Accomplishments**

**Current Grants**

**Awards and Recognition**

**ALARC in the News**

**Events and Outreach**

**Recent Publications**



### **FEATURED RECENT ACCOMPLISHMENT**

**Field marking of arthropods for dispersal research.** The protein immunomarking procedure is a powerful method for marking insects for ecological studies. Scientists at the Arid-Land Agricultural Research Center (ALARC) in Maricopa, AZ pioneered the procedure. For over a decade they have been tagging naturally occurring insects directly in the field with various protein solutions using conventional spray equipment. The proteins are found in common food products such as chicken egg whites (albumin) and bovine milk (casein). After the mark(s) are applied in the field the insects from surrounding areas are collected over time and space and examined for the presence of the marker(s). The presence of the protein on field-collected insects is detected using protein-specific (e.g., albumin and casein) enzyme-linked immunosorbent assays (ELISA). These relatively simple, cost efficient, and sensitive ELISAs are very similar to the assays used by medical researchers for detecting for pregnancy, drug usage, and diseases (Fig. 1).



***Fig. 1. An ELISA depicting the presence (colored dots) of a protein mark on a field collected insect. The three darker blue wells indicate positive tests for the protein.***

ALARC scientists recently used the protein immunomarking method in collaboration with researchers from the University of California at Santa Cruz to quantify lygus bug dispersal at a commercial organic strawberry farm that was intra-planted every 50 rows with a row of alfalfa (Fig. 2). Alfalfa is a

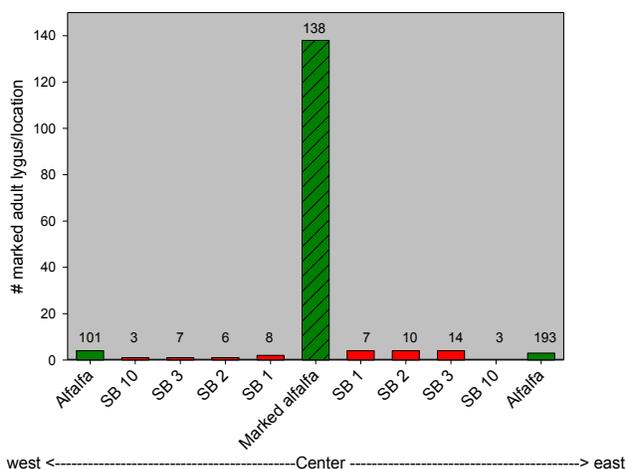
highly attractive crop to the lygus bug and is often used to “trap” or lure the lygus away from the economically valuable strawberries. The movement of lygus adults and nymphs from a protein-marked alfalfa trap crop (Fig. 3) into adjacent strawberry rows or distant trap crops (Fig. 2) was examined using a chicken egg albumin lygus mark-capture ELISA.

**Fig. 2. Study site showing a strip of alfalfa (trap crop) planted every 50 rows in a commercial organically grown strawberry field (near Watsonville, CA).**



The study revealed that vast majority of lygus bugs are attracted to the alfalfa rows and that the lygus marked in the central location remained in the alfalfa trap crop rather than dispersing out into strawberry rows (Fig. 4). The tempering of lygus movement by alfalfa in organic strawberries is a key component of successful trap cropping. It is anticipated that both organic and conventional strawberry growers will adopt this environmentally benign cultural insect control tactic.

**Fig. 3. ALARC scientists Scott Machtley and James Hagler with Janet Bryer, Diego Nieto (not shown), and Sean Swezey (not shown) from UC Santa Cruz applying an egg albumin protein solution to lygus bugs inhabiting a strip of alfalfa embedded in an organic strawberry field.**



**Fig. 4. Total number of adult lygus bugs recovered with an egg albumin mark at each location. Adults were collected from center (marked) alfalfa trap crops, strawberry (SB) rows 1, 2, 3, and 10 adjacent to the marked location, east/west alfalfa trap crops (50 rows from center trap crops). Numbers above data points refer to number of lygus bugs collected from each location.**

Using this immunomarking technique, ALARC scientists are collaborating with researchers throughout the world to study the dispersal patterns of a wide variety of agricultural and household pests (e.g., lygus, spotted-wing *Drosophila*, bed bugs), natural enemies (insect predators and parasitoids), and pollinators (e.g., honey bees, bumble bees). Every year, more and more people are finding ways to use immunomarking as part of their research thanks to the low cost and simplicity of this system.

### Read More

Swezey, S.L., D.J. Nieto, J.R. Hagler, C.H. Pickett, J.A. Bryer, and S.A. Machtley. 2013. Dispersion, distribution and movement of *Lygus* spp. (Hemiptera: Miridae) in trap-cropped strawberries. *Environmental Entomology*. 42: 770-778.

Swezey, S.L., D.J. Nieto, C.H. Pickett, J.R. Hagler, J.A. Bryer, and S.A. Machtley. 2014. Spatial density and movement of the *Lygus* spp. parasitoid *Peristenus relictus* (Hymenoptera: Braconidae) in organic strawberries with alfalfa trap crops. *Environmental Entomology*. 43 (2): 363-369.

**Funding.** This project was funded, in part, by the USDA-CSREES Pest Management Alternatives Program (PMAP).

(Contact: [James.Hagler@ars.usda.gov](mailto:James.Hagler@ars.usda.gov), [Scott.Machtley@ars.usda.gov](mailto:Scott.Machtley@ars.usda.gov))

### OTHER RECENT ACCOMPLISHMENTS

**Identification of critical genes in the western tarnished plant bug.** Although the western tarnished plant bug is widely recognized as an important crop pest in the western U.S., little information is available regarding its molecular biology and physiology. We



identified 65 members of a gene family (the ABC transporters) known from other organisms to function in protein synthesis, reproductive development, and the elimination of toxins. A subset of these genes likely to function in pesticide resistance was further identified. These results suggest possible targets for genetic-based pest control and provides a broad baseline for future research to develop species-specific non-insecticidal control tactics. Contact: [Joe.Hull@ars.usda.gov](mailto:Joe.Hull@ars.usda.gov)

**Host plant induction of detoxification enzymes in relation to insecticide resistance.**

Insects that feed on many types of host plants are often exposed to a variety of plant defensive chemicals that are toxic to the insect. The mechanisms these insects use to eliminate or detoxify plant defensive chemicals may also deactivate certain insecticides. We identified a suite of detoxification enzymes in the silverleaf whitefly that are stimulated when the insects feed on specific hosts. Increased tolerance to selected insecticides was also associated with increased activity of the detoxification enzymes. Improved understanding of the influence of host plant on the effectiveness of insecticides is an important consideration to the design of sustainable management strategies for the silverleaf whitefly. Contact: [Steven.Castle@ars.usda.gov](mailto:Steven.Castle@ars.usda.gov)

**Novel molecular mechanisms associated with pink bollworm resistance to transgenic Bt cotton.** Although the pink bollworm is a major cotton pest worldwide, the advent of insecticidal Bt cotton has revolutionized management and suppression of this pest. However, recent emergence of highly-resistant field populations of pink bollworm in Asia accentuates the need to understand the molecular basis of Bt-resistance. Research at ALARC scientists in collaboration with the University of Arizona, analyzed field-collected pink bollworm from India, they found a diversity of genetic changes conferring resistance, including a novel mechanism called alternative splicing. These findings



represent the first example of alternative splicing associated with Bt resistance that developed in the field. Because a diversity of resistance mechanisms were identified from only a few field-collected pink bollworm, current methods to detect resistance based on specific genetic changes may not be effective. Contact: [Jeff.Fabrick@ars.usda.gov](mailto:Jeff.Fabrick@ars.usda.gov)

**Characterization of the omega-3 fatty acid desaturase gene family in cotton.** Cotton plants are sensitive to abiotic stresses including sudden episodes of cold temperature during the early parts of the growing season, and heat and drought encountered during the latter parts of the growing season. ALARC scientists in collaboration with scientists at the University of North Texas, Cornell University, Brigham Young University, and West Virginia University, identified and characterized a large gene family in cotton that is responsible for the production of omega-3 fatty acids. Omega-3 fatty acids are involved in both chilling adaptation as well as heat and drought response in plants. Knowledge of this gene family in cotton provides key insight to the genes that underlie abiotic stress response in commercially important varieties. Notably, a single gene was identified whose expression was upregulated during both drought and cold temperature response in cotton. This provides information that will underpin future efforts to improve cotton germplasm using molecular breeding approaches. Contact: [John.Dyer@ars.usda.gov](mailto:John.Dyer@ars.usda.gov)

**Development of direct seeding methods for guayule, a natural source for rubber.** Guayule, *Parthenium argentatum*, is a desert shrub that produces latex in bark tissues and represents a potential domestic source of natural rubber. One of the major challenges for cultivating guayule, however, is that the plant must be hand-sown using seedlings, which significantly increases the costs and labor associated with crop production. ALARC scientists with the University of Arizona, Cornell University, West Virginia University, and Seed Dynamics Incorporated of Salinas, California, developed direct-seeding methods for guayule and optimized conditions for seed germination and seedling establishment. The results of these studies will directly impact the guayule industry and underpin future efforts to further improve guayule cultivation and agronomics.



**Determination of the upper lethal growing-season-long-average air temperature for wheat.** In order to adapt wheat production to global warming, a dataset was needed to test the high-temperature aspects of wheat growth models. ALARC scientists in collaboration with scientists at the University of Arizona, Tucson, Arizona, conducted a Hot Serial Cereal Experiment. "Cereal" because the crop was wheat, "Serial" because the wheat was planted about every six weeks for two years in hot Arizona, and "Hot" because on six of the planting dates, infrared heaters were deployed above some of the plots to provide additional warming. Results showed that yields decreased as season-long-average air temperatures increased above 15°C, reaching a crop-failure lethal temperature at 32°C. These results should ultimately lead to improved wheat growth models that can be used to help develop strategies for adapting to global warming, which will benefit all consumers of wheat products including wheat-fed meat production. Contact: [Jeffrey.White@ars.usda.gov](mailto:Jeffrey.White@ars.usda.gov)

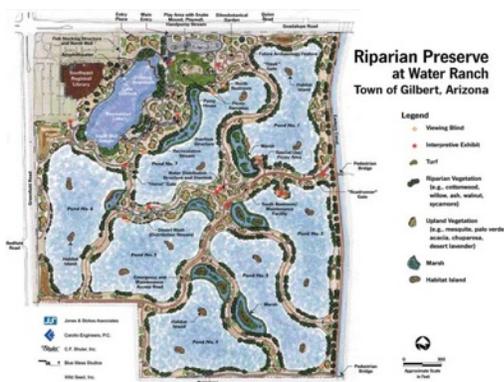
**Irrigation scheduling using real-time spatial information.** Improved irrigation scheduling is needed in water-limited regions where surface irrigation methods still predominate. ALARC researchers developed an irrigation decision technology for applying variable irrigation scheduling to cotton borders utilizing real-time aerial and ground-based remote sensing information. This technology will help optimize variable rate irrigation

systems through improved forecasting of irrigation amounts and dates. The research benefits irrigation managers of large cotton farms using surface irrigation systems, irrigation consultants, and State Water Resource Departments in the arid southwestern U.S. Contact: [Doug.Hunsaker@ars.usda.gov](mailto:Doug.Hunsaker@ars.usda.gov)

### **Nitrogen fertilizer management for durum wheat cultivars in the Southwest.**

Optimizing nitrogen (N) management and using cultivars with high N use efficiency (NUE) are important for durum wheat producers in irrigated production systems. ALARC researchers collaborated with scientists at the University of Arizona to conduct field experiments with six durum wheat cultivars and five or six levels of N treatment for two growing seasons (2010-2011 and 2011-2012) to determine NUE, and yield of durum wheat cultivars under irrigated desert conditions. Recovery efficiency of N fertilizer was very high (63 to 79%) and fertilizer rate had a positive effect on nearly all agronomic variables in both seasons. Although there was variation in grain yield and NUE among durum wheat cultivars, N fertilizer effects were more significant than cultivar effects. Results show that grower decisions on optimal N rate will have more impact than cultivar selection and that development of practical guidelines for optimizing durum N fertilizer management will benefit durum wheat growers in the southwestern U.S. contact:

[Kevin.Bronson@ars.usda.gov](mailto:Kevin.Bronson@ars.usda.gov)



### **Development of antibiotic resistance in soils receiving reclaimed municipal wastewater for groundwater recharge.**

The application of reclaimed municipal waste water containing antibiotics may lead to the development of increased antibiotic resistance in soil microorganisms receiving these waters. ALARC scientists found that soil organisms isolated from the top 30 cm of a groundwater recharge facility were resistant to the antibiotics lincomycin, penicillin, and vancomycin. However, the level of resistance in the recharge basins was similar to organisms from a recharge facility that only receives ground water for recharge.

Furthermore, resistance to four antibiotics in Enterococcus was higher in the control soils that had only received groundwater soils receiving treated effluent. Comparing the development of antibiotic resistance in soil bacteria at these two sites will increase awareness of the environmental and public health impacts of using reclaimed water for groundwater recharge and irrigation of municipal areas. Contact:

[Clinton.Williams@ars.usda.gov](mailto:Clinton.Williams@ars.usda.gov)

### **CURRENT GRANT AWARDS (\*NEW)**

\*Improving Nitrogen Fertilizer Management and Fate of Nitrogen in Sprinkler-Irrigated Cotton, Cotton Incorporated (PI **Kevin Bronson**) 2015

\*Prospective Resistance Management: Empowering Growers to Partition Chemistry in Space and Time, USDA-NIFA (PI Peter Ellsworth, Co-PIs **Steve Castle**, Nilima Prabhaker (UC-Riverside), Yves Carrière, John Palumbo, Al Fournier, Wayne Dixon, Lydia Brown) 2014-2016

\*Prospective Resistance Management: Empowering Growers to Understand and Exploit Refugia (PI Peter Ellsworth, Co-PIs **Steve Castle**, Nilima Prabhaker, Yves Carrière, John Palumbo, Al Fournier, Wayne Dixon, Lydia Brown) 2015-2017

Selecting and Using Bt-Resistant Strains of Two Key Pests to Understand Resistance and Characterize Responses to Novel Toxins, CRADA Pioneer Hi-Bred International (PI **Jeff Fabrick**) 2013-2016.

Identification of Factors Mediating Environmental Acclimation in *Lygus hesperus*, Cotton Incorporated (PIs **Colin Brent Joe Hull, Jeff Fabrick**) 2014-2015.

The Integrated Program to Accelerate Breeding of Resilient, more Productive Beans for Smallholder Farmers, Pennsylvania State University (PI **Jeff White**) 2013-2015.

Evaluating and Predicting H2O Consumption by Irrigated Agriculture in Israel and US: Inverse Biophysical Modeling Utilizing Spaceborne Imagery, Binational Agricultural Research and Development Fund (BARD) (PI **Andy French**) 2012-2015.

Accelerated Development of Commercial Hydrotreated Renewable Jet (HRJ) Fuel from Redesigned Oil Seed Feedstock Supply Chains, USDA-NIFA/DOE Biomass Research and Development Initiative (PI T. Isbell, Co-PIs **John Dyer**, Mike Gore, D. Long, D. Archer, S. Frey, D. Galloway, T. Tomlinson) 2012-2016.

Securing the Future of Natural Rubber – An American Tire and Bio-energy Platform from Guayule, USDA-NIFA/DOE Biomass Research and Development Initiative (PI H. Colvin, Co-PIs Mike Gore, C. McMahan, **John Dyer**, A. Halog, J. Mitchell, P. Zorner, Collaborator, **Doug Hunsaker**) 2012-2016.

Impact of Bioenergy Crops on Pests, Natural Enemies and Pollinators in Agricultural and Non-Crop Landscapes, USDA-NIFA-AFRI (Co-PI **James Hagler** with T. Kring and R. Weidenman, University of Arkansas; B. McCornack, Kansas State University; K. Giles, Oklahoma State University) 2011-2016

Managing Pierce's Disease in Arizona Vineyards, USDA Specialty Crop Block Grant Program (PI **Steve Castle**) 2012-2015.

Comparison of cotton simulation models for Arizona production systems, Cotton Incorporated (PI **Kelly Thorp**) 2013-2015.

Applying Proximal Sensing to Enhance Upland Cotton Yield Trials, Cotton Incorporated (PI **Andy French**) 2013-2015.

High-Throughput Phenotyping Using Portable LIDAR, Cotton Incorporated (PI **Andy French** with Co-PIs M. Gore, Cornell University and P. Andrade-Sanchez, University of Arizona) 2012-2015.

Investigation into Effects of Soil Moisture Depletion on Vegetable Crop Uptake of Microcontaminants under Recycled Water Irrigation, USDA-NIFA-AFRI (PI **Clinton Williams** with C. Ray, University of Hawaii) 2011-2015

## RECENT PROFESSIONAL AWARDS AND RECOGNITION



**Joe Hull**, Pacific Branch, Entomological Society of America (PBESA) Physiology, Biochemistry, and Toxicology Award: This award recognizes an outstanding record of accomplishment in the study of biochemistry, microbiology, toxicology, endocrinology, cytology, molecular biology, allelochemicals, pheromones, hormones or metabolism. Joe was recognized at the PBESA meeting in April.

**James Hagler**, *PBESA Award for Excellence in Integrated Pest Management*: This award recognizes an individual who has made outstanding contributions with a direct relation to integrated pest management. James was recognized at the PBESA meeting in April.



**Kelly Thorp**, *2015 American Society of Agricultural and Biological Engineers (ASABE) Superior Paper Award*: The paper evaluated a cotton crop growth model for simulating effects of management and climate change on cotton growth and evapotranspiration in an arid environment. ALARC co-authors include **Doug Hunsaker**, **Jeff White** and **Bruce Kimball**. All authors will be recognized at the annual ASABE meeting in July.

**Clinton Williams** has been selected as a representative to Pharmaceuticals in Water Working Group. Clinton will serve on the Pharmaceuticals in Water Steering Committee.

## **ALARC IN THE NEWS**

**NASA's ECOSTRESS will Monitor Plant Health**: Nasa, in partnership with USDA-ARS, and multiple universities will develop ECOSTRESS, a space-based instrument that will enable study of how effectively plants utilize water. ([link](#))

**High Throughput Phenotyping at the USDA-ARS and Maricopa Agricultural Center**: USDA-ARS, Kansas State University and University of Arizona are partnering on the development of high throughput phenotyping to accelerate crop improvement. ([link1](#)) ([link2](#))

## **RECENT EVENTS AND OUTREACH**

**June 2014**, Drs. Jeff White and John Dyer hosted a traveling Phenomics Workshop for Grain Legume Researchers. The workshop's objective is to help grain legume researchers learn about promising techniques in field phenomics and shovelomics. This workshop helps build collaboration between USDA-ARS, Kansas State University (under the NSF Plant Genome project), Dr. Jonathan Lynch's lab at Penn State University and their Apache Root Biology Center located in Willcox, Arizona. Also attending the workshop was Dr. Hesham Agrama and Dr. Ousmane Boukar with the International Institute of Tropical Agriculture (IITA) located in Oyo State, Nigeria, Dr. Abiezer Gonzalez with the University of Puerto Rico, Dr. Jana Kholova with the International Crops Research Institute for Semi-Arid Tropics (ICRISAT), Dr. Steve Bebe and Dr. Arnulfo Polania with Centro Internacional de Agricultura (CIAT) located in Cali, Columbia, and Dr. Carlos Rios with the USDA-ARS Tropical Agricultural Research Station, located in Mayaguez, Puerto Rico, and Dr. Jennifer Trapp with Washington State University.

**June 2014**, USDA-ARS, Maricopa, AZ again hosted the Summer Ag Institute. This is a group of K-12 teachers, who embark on a week-long tour throughout Arizona. This adventure is designed to teach them about food and fiber production, and help them 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 the three research units, as well as seeing a tractor for high-throughput phenotyping, providing the group with an overview for why we need this approach for heat and drought research and how the sensors on the tractor make it possible.

**June 2014**, USDA-ARS, Maricopa, AZ hosted a group of students/faculty from Central Arizona College (an HSI), located in Maricopa, AZ. The group consisted of 18 students and 9 faculty members interested in learning about the agricultural research we do at the Center.

**June 2014**, the EEO Committee observed Lesbian, Gay, Bisexual and Transgender (LGBT) month by showing a Movie at Lunch time. The movie included three short and fun videos, along with popcorn, soda, and candy. This was a great way for employees to take a break from their busy schedules, share thoughts, learn, and enjoy movie & popcorn.

**July 2014**, USDA-ARS in Maricopa, AZ held its annual *Bring your Kids to Work* day. This was a great opportunity for our kids to see, touch, and feel the science that their parents are conducting. The day was filled with activities that included a Farm Field Tour, Isolating their own DNA, Robotics-Lab Automation, a Greenhouse tour, Computer/Intranet programming, Insects under the Microscope, Thermal Imaging, and Polymers to Slime. It was a wonderful day for the kids, as well as the parents (*parent's written consent granted for photos*).



**June-July, 2014**, USDA-ARS, Maricopa, AZ scientists from all 3 research units hosted 13 high school intern and one teacher as part of a South Mountain Community College (SMCC) led Undergraduate Bioscience Engagement Track (UBET) program. The program aims to increase science and engineering training in local high schools, particularly for minority students. The students conducted an individual research project in their mentors laboratory while earning college level credits. The interns developed a poster of their projects that were presented at the Center and then at SMCC for a final grade. This marks the third year that USDA-ARS has hosted interns from this program and a group of 17 students and teachers will participate in summer of 2015. Enjoy a video of the program put together by Tempe Union High School District.

<http://www.youtube.com/watch?v=IyYKsi5v1cE&feature=youtu.be>



**July 2014**, Dr. Jeff White (*left in photo*) provided a tour to a researcher from Thailand, and 3 researchers from Penn State University. The group was introduced to equipment and underlying approaches for field-based high-throughput phenotyping. The group is part of the Arizona Root Biology Center and also toured labs in the Plant Physiology and Genetics Research Unit.



**July 2014**, Dr. Paul Sanchez with the Plant Physiology and Genetics Research Unit hosted and provided a tour to the Arizona Knights of Rizal. This group is a civic, cultural, non-political, non-profit, non-sectarian organization with the general purpose and specific objective to study and spread the ideals, teachings and the exemplary life of Dr. Jose P. Rizal, the Philippine National hero and the pride of the Malayan race.

**August 2014**, USDA-ARS, Maricopa, AZ hosted East Valley Chemistry Club, a group composed of home-school high school students. The club is a group of home-schooled teens studying chemistry. The club has been meeting weekly since June 2014 to interact with each other, work on lessons, and conduct chemistry experiments. Center scientists provided chemistry related activities for the students and discussed and demonstrated a number of scientific instruments used in chemistry.

**September**, The USDA-ARS, Maricopa, AZ Seminar Series kicked-off its 8<sup>th</sup> year. The series this year focused on research being conducted by the scientific staff of the Center and included a wide diversity of topics in entomology, plant science and engineering.



**September 2014**, Joe Hull, Brenda Singleton and Colin Brent attended Central Arizona Colleges (CAC) Science, Technology, Engineering, and Math (STEM) night at the colleges Maricopa campus, located in Maricopa, AZ. They represented the USDA-ARS and presented some of the research being conducted at our research center. The STEM program is an innovative college enrichment curriculum for high school and college-aged students in Pinal County. The goal is to encourage and increase the presence of historically underrepresented groups in the

career fields of science, technology, engineering and math and assist in the transfer to a 4 year college or university.

**October 2014**, USDA-ARS, Maricopa, AZ hosted the 3<sup>rd</sup> annual Technical Meeting and Project Review for the Biomass Research and Development Initiative (BRDI) guayule Grant. Attendees were from Cooper Tire & Rubber, USDA-ARS (Maricopa, AZ, Albany, CA, Beltsville, MD), PanAridus LLC, Cornell University, and Arizona State University. The team visited & toured PanAridus germplasm development and rubber extraction facility in Casa Grande, AZ, and the field trial locations at Maricopa Agricultural Center in Maricopa, AZ. Research presentation focused on a wide variety of topics including sustainability Analysis,

guayule genome sequencing and development of molecular breeding tools, direct seeding, irrigation, and post-harvest processing for rubber production.

**October 2014**, ALARC and the University of Arizona, Maricopa Agricultural Center held Farm Day. This event brought in local vendors, farmers, and families throughout the community to learn about agriculture and how it affects their communities. Activities included: insect zoo, insect sounds, cotton 101, auto-guidance tractor-ride along, hayrides for the kids to the University of Arizona Farm Village & cotton gin, cricket spitting, and face painting. ALARC Scientist and Technicians put together displays on Biofuel crops, Entomology, Photosynthesis, Irrigation, Remote sensing, Natural Rubber from guayule, and Farm Equipment. A local group brought along a number of antique tractors for display and rides and Pinal County Master Gardeners were also on hand.



**November 2014**, USDA-ARS-ALARC in Maricopa, AZ hosted an annual visit by students and faculty from the University of Chapingo, Chapingo, Mexico. The group consisted of sixty-eight undergraduate Irrigation Engineering students and four faculty members. Drs. Eduardo Bautista, Andrew French and Kevin Bronson discussed ongoing research in the areas of irrigation modeling, irrigation management, and remote sensing in irrigated agriculture. The group also visited the facilities of the Salt River Project, the Central Arizona Project, and the Maricopa Agricultural Research Center.

**February 2015**, John Dyer, Jeff Peterson, James Hagler and Andy French represented the ALARC at the annual Phoenix College USDA Career Pathways Fair located in Phoenix, AZ. The personnel visited with students and faculty to promote research activities and internship opportunities within the ARS, in general, and the Maricopa research lab, specifically. Approximately 30 people stopped by the table over a two-hour period, and pamphlets, brochures, and other promotional materials were passed out. We collected names of students interested in internships.



## RECENT JOURNAL PUBLICATIONS

### Entomology

Asiimwe, P., **Naranjo, S.E.**, Ellsworth, P. 2014. Effects of irrigation regime on interactions between *Lygus hesperus*, insecticides and predators in cotton. *Environmental Entomology*. 43:263-273. ([PDF](#))

**Brent, C.S., Hull, J.J.** 2014. Characterization of male-derived factors inhibiting female sexual receptivity in *Lygus hesperus*. *Journal of Insect Physiology*. 60:104-110. ([PDF](#))

**Byers, J.A.** 2014. Response to Martini and Habeck: Semiochemical dose-response curves fit by kinetic formation functions. *Journal of Chemical Ecology*. 40:1165-1166. ([PDF](#))

**Byers, J.A.**, Birgersson, G., Francke, W. 2013. Aggregation pheromones of bark beetles, *Pityogenes quadridens* and *P. bidentatus*, colonizing scotch pine: olfactory avoidance of interspecific competition. *Chemoecology*. 23:251-261. ([PDF](#))

**Byers, J.A., Naranjo, S.E.** 2014. Detection and monitoring of pink bollworm moths and invasive insects using pheromone traps and encounter-rate models. *Journal of Applied Ecology*. 51(4):1041-1049. ([PDF](#))

Callier, V., Shingleton, A.W., **Brent, C.S.**, Ghosh, S.M., Kim, J., Harrison, J. 2013. The role of reduced oxygen in the developmental physiology of growth and metamorphosis initiation in *Drosophila*. *Journal of Experimental Biology Online*. 216:4334-4340. ([PDF](#))

**Castle, S.J., Merten, P.**, Prabhaker, N. 2013. Comparative susceptibility of *Bemisia tabaci* to imidacloprid in field- and laboratory-based bioassays. *Pest Management Science*. 70:1538-1546. ([PDF](#))

- Fabrick, J.A.**, Ponnuraj, J., Singh, A., Tanwar, R.K., Unnithan, G., Yelich, A.J., Li, X., Carriere, Y., Tabashnik, B.E. 2014. Alternative splicing and highly variable cadherin transcripts associated with field-evolved resistance of pink bollworm to Bt cotton in India. *PLoS One*. 9(5):e97900. ([PDF](#))
- Hagler, J.R., Machtley, S.A., Blackmer, F.** 2015. A potential sampling error associated with insect protein mark-capture data. *Entomologia Experimentalis et Applicata*. 154:28-34. ([PDF](#))
- Hagler, J.R., Naranjo, S.E., Machtley, S.A., Blackmer, F.** 2014. Development of a standardized protein immunomarking protocol for insect mark-capture dispersal research. *Journal of Applied Entomology*. 138:772-782. ([PDF](#))
- Hull, J.J., Brent, C.S.** 2014. Identification and characterization of a sex peptide receptor-like transcript from the western tarnished plant bug, *Lygus hesperus*. *Insect Molecular Biology*. 23:301-319. ([PDF](#))
- Hull, J.J.**, Wang, M. 2014. Molecular cloning and characterization of G alpha proteins from the western tarnished plant bug, *Lygus hesperus*. *Insects*. 6(1):54-76. ([PDF](#))
- Hull, J.J.**, Chaney, K., Geib, S.M., **Fabrick, J.A., Brent, C.S.**, Walsh, D., Lavine, L.C. 2014. Transcriptome-based identification of ABC transporters in the western tarnished plant bug *Lygus hesperus*. *PLoS One*. 9(11):e113046.doi:10.1371/journal.pone.0113046. ([PDF](#))
- Kawai, T., Nagata, K., Guo, L., Liu, D., Suzuki, T., Katayama, Y., Hayakawa, K., Lee, J., Nagamine, T., **Hull, J.J.**, Matsumoto, S., Nagasawa, H., Tanokura, M. 2014. Identification of functionally important residues in the silkworm pheromone biosynthesis-activating neuropeptide receptor, an insect ortholog of the vertebrate Neuromedin U Receptor. *Journal of Biological Chemistry*. 27:19150-19163.
- Klick, J., Lee, J.C., **Hagler, J.R.**, Bruck, D.J., Yang, W.Q. 2014. Evaluating *Drosophila suzukii* (Diptera: Drosophilidae) immunomarking for mark-capture research. *Entomologia Experimentalis et Applicata*. 152:31-41. ([PDF](#))
- Kumar, R., Tian, J.C., **Naranjo, S.E.**, Shelton, A.M. 2014. Effects of Bt cotton on Thrips tabaci and its predator, *Orius insidiosus*. *Journal of Economic Entomology*. 107:927-932. ([PDF](#))
- Luthi, C., Alvarez-Alfageme, F., Li, Y., **Naranjo, S.E.**, Higgins, T.J.V., Romeis, J. 2015. The potential of the bean alpha-amylase inhibitor alphaAI-1 to control true bugs (Hemiptera). *Journal of Applied Entomology* 139: 192-200. ([PDF](#))
- Meissle, M., **Naranjo, S.E.**, Kohl, C., Riedel, J., Romeis, J. 2014. Does the growing of Bt maize change populations or ecological functions of non-target animals compared to the growing of conventional non-GM maize? A systematic review protocol. *Environmental Evidence*. 3:7. ([PDF](#))
- Naranjo, S.E.**, Ellsworth, P., Frisvold, G. 2015. Economic value of biological control in IPM of plant systems. *Annual Review Of Entomology*. 60:621-645. ([PDF](#))
- Penick, C.A., **Brent, C.S.**, Dolezal, K., Liebig, J. 2014. Neurohormonal changes associated with ritualized combat and the formation of a reproductive hierarchy in the ant *Harpegnathos saltator*. *Journal of Experimental and Environmental Biology*. 217:1496-1503. ([PDF](#))
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