**Condition Change: UC ANR contributed to increased agricultural efficiency and profitability**

*Sustainable Food Systems*

**Issue**

California is a national leader in agricultural production, leading the country in cash receipts for agricultural products, with farms and ranches receiving over $50 billion for their output. The state accounts for almost half of the country’s fruit and nut production, and over half of the vegetable production. The state’s farmers and ranchers must innovate and adapt to technical, social, and environmental challenges to maintain the economic vigor of California’s agricultural food production. Factors such as high input prices (e.g. labor, fertilizers, and pesticides) and regulations affect the profitability of farm and ranch businesses. These factors often more adversely affect small-scale farmers because they often lack the resources or skills that larger farmers have.

**Methods**

UC ANR creates and extends new knowledge about agricultural production from variety trials to post-harvest.

A UC Agricultural Experiment Station researcher at the UC Riverside location is working on mechanisms that regulate tolerance to abiotic stresses in plants. Increasing food demand and shrinking land availability are likely to drive crop production globally to bring more marginal production areas under cultivation. In order to make production sustainable in such circumstances, information is needed on both the mechanisms of plant responses to stress and new varieties that are able to tolerate drought, salinity, water-logging, and other stresses. This project focused on understanding these stresses in the world’s most important staple crop, rice. This has the potential to improve the long-term prospects for stable food production by the world’s poorest farmers. In addition, this work provides education and training opportunities for young scientists from around the world, ensuring that the technology development happening in California today is embedded in the global science base for tomorrow (Julia Bailey-Serres).

A UC Cooperative Extension (UCCE) post-harvest study focused on reducing the cracking of sweet cherries. This project developed close working relationships with six of the major sweet cherry packaging facilities in the state. The study found that by using commercially available techniques and surface drying prior to storage, the risk of introduced cracked cherries goes down from 35 lb. to 19 lb. per 100 lb. of packaged product (taking into account the yearly conditions of the study). In addition, it was observed that cherry cracking severity can be significantly reduced by adding Sucrose and CaCl2 to the water, and by gradually reducing the initial temperature of the cherries to their final storage temperature (Irwin Donis-Gonzalez).

A collaborative UCCE project focused on small farm risk. It is part of a public and private, multi-state and multi-agency collaboration that developed tools and implemented educational programs to help small farm clientele improve businesses and risk management skills. The collaboration included colleagues from University of Wyoming, Colorado State, and University of Nebraska, and was funded by the USDA Risk Management Agency and the CDFA Specialist Crops Block grant program. UCCE contributed to the “Ag in Uncertain Times” online education program, provided in English and Spanish, with support from the Western Center for Risk Management Education. In addition, risk management tools and materials developed are available at the eRight Risk California website. This multi-state effort has given small farmers access to expertise, tools, resources, and educational opportunities on business and risk management previously not available (Ramiro Lobo).

Another UCCE project focused on small farm sustainability continued work in the Sierra Foothills. Participatory workshops focused on agricultural efficiency through mulching to improve soils and pruning to improve yield and reduce pesticide use. Other workshops focused on building producers’ skills in business management. Peer-to-peer learning was used as a critical component of the training (Cindy Fake and Dan Macon). One effort supported by the CDFA Specialty Crop Block Grant focused on mandarin orchards, and close to 3,000 growers were provided science-based tools for citrus production (Cindy Fake).

A UCCE project working with USDA Crop Protection Network (CPN) has the long-term goal to increase the use and adoption of virus-tested sweet potatoes by commercial growers, through Extension and improvements in facilities and procedures to increase the number of available plants. Plants produced within the CPN program reduce the potential for disease spread and generally improve yield and quality. This effort is in close collaboration with UC Davis Foundation Plant Services, which provides facilities, staff, and support. Meetings and other extension efforts were held in New Orleans, Sacramento, and Merced (Scott Stoddard).

Another UCCE project focuses on sustainable agronomic crops production in the Sacramento-San Joaquin Delta, including corn, rice, dry beans, and winter cereal crops. Findings from variety trials and other research were extended through grower meetings. In particular UCCE is developing expertise and outreach in corn nitrogen management, a critical issue for California agriculture and reported through the Irrigated Lands Regulatory Program. (Michelle Leinfelder-Miles). Ongoing, collaborative yearly rice variety trials test the performance of preliminary and advanced rice varieties at eight locations across the rice growing area of California. Information on rice productivity was shared with clientele through newsletters, blog posts, the UC Rice-online website, five educational meetings, and additional clientele consultations (Luis Espino).

As a result of UC ANR research and extension, participants learned and adopted agricultural management practices. Outcomes with specific indicators follow.

**Outcomes**

**Participants learned about farm business and risk management practices.**

* Local growers in San Diego County increased understanding and ability to manage risks affecting their agricultural businesses, per exit evaluations at seminars and feedback from participants. (Ramiro Lobo)

**Participants implemented farm business and risk management practices.**

* From surveys over the last five years, farm business planning has significant impacts on small farm and ranch profitability in Placer and Nevada Counties. Over 86% of participating businesses reported being profitable and paying themselves a salary, as compared to the 26% in the 2017 Census of Agriculture. In 2019 the following specific outcomes were measured:
	+ 68 producers developed and implemented action plans resulting from what they learned in the “Start a Farm” class, Beginning Farming Academy, and/or Farm Business Planning.
	+ 35 producers decided an appropriate enterprise mix, marketing strategies, and essential capital purchases for their operations.
	+ 10 participants in the Farm Business Planning course identified key risks and developed a risk assessment for their operation.
	+ 10 producers conducted an in-depth economic analysis of their business; analyzing the operational components; evaluating costs of production and marketing; projecting potential sales; and assessing the profitability of each enterprise in order to inform business decisions.
	+ 10 producers developed and implemented financial analysis and recordkeeping systems, including enterprise analysis, cash flow, and profit and loss. This improved business decision-making and helped improve profitability. (Cindy Fake and Dan Macon)

**Participants intend to adopt recommended practices for plant production.**

* After agronomic winter field crops meetings, 96% of 34 participants indicated they would use the information in the next 12 months. (Michelle Leinfelder-Miles)

**Participants adopted recommended practices for plant production.**

* 194 acres of citrus are now farmed using best management practices. Of the 63 citrus growers responding to surveys about citrus production practices in the Sierra Foothills, 98% reported they now prune their citrus orchards and 71% now use mulch; prior to the UCCE research and extension on mulching it was only 18%. Cindy Fake)
* The number of virus-tested sweet potato plants produced by UC Davis Foundation Plants Services has increased gradually over the past five years. Adoption by growers in California is very high, about 80%, based on information from the main seed producer in the state. (Scott Stoddard)

**Change in conditions**

* **Improved productivity**: During 2019, one rice variety (S-202) was released for commercial production. The variety trials’ results aid growers in selecting varieties better adapted to their location. Approximately 95% of California’s rice acreage is planted with varieties that have been evaluated in the variety trials, indicating very high levels of adoption of improved varieties. These varieties have allowed growers to maintain high productivity, averaging 8,500 pounds/acre in the past ten years, and very good grain quality. (Luis Espino)
* **Reduced loss:** Some facilities within the California sweet cherry industry utilized the post-harvest study advancements and information which enabled marketing a higher quality product and reduced product waste. Given confidentiality agreements the exact amount of reduced loss is not known. However, knowing that California produced around 50,000 US TONS of sweet cherries in 2019, and using the research findings it can be estimated that there is the potential to reduce the incidence of cracked cherries from around 17,500 US TONS to around 9,500 US TONS statewide. (Irwin Donis-Gonzalez)

These measured outcomes strengthened diverse California farm businesses by helping to increase their economic returns given increased yield, reduced inputs, or improved business management and marketing. These outcomes contribute to increased agricultural efficiency and profitability; and thus, the public value of promoting economic prosperity in California. In 2017, California farms and ranches increased cash receipts for their output by almost 6% compared to the previous year, collecting over $50 billion.

*Endemic and Invasive Pests and Diseases*

**Issue**

Pests, diseases, and invasive plants decrease California’s agriculture efficiency and profitability. In agricultural systems, pests reduce yields, render crops unmarketable, and weeds make rangeland unpalatable to livestock. Just one species can be detrimental to crop production and revenues. The invasion of spotted-wing drosophila, for example, caused conventional raspberry growers in California to lose $36.4 million in revenue between 2009 and 2014, and was on track to reduce California raspberry yields by as much as 50%. . As the population increases, crop production must increase to meet the greater food demands. Science-based information is needed for land owners, managers, and policy makers to develop practices and policies that sustain economic vitality while protecting environmental quality.

**Methods**

UC ANR partners with public, governmental, and private groups to extend new knowledge and develop integrated pest management plans to increase agriculture efficiency and profitability.

UC Agriculture Experiment Station (AES) scientists study early detection of pests to help avoid expensive pest management and disruption in commerce. At the UC Davis AES location a rapid assay is being developed to detect the spinach downy mildew pathogen, which will guide management and production decisions (Krishna Subbarao). Research at the UC Riverside AES location includes developing the first antibody-based diagnosis of citrus greening disease using pathogen effectors as detection markers (Wenbo Ma); developing decision-support for sugar-beet nematodes to know when populations are large enough to trigger a pest management tactic (Ole Becker); and synthesizing and field-testing sex attractant pheromones of North American wireworm species (Jocelyn Millar).

University of California Cooperative Extension (UCCE) research and extension includes practices to reduce the introduction or spread of invasive species. For example, to address the issue that weedy rice infestations were not being reported, the UCCE rice team continues a collection protocol they developed in 2018 requiring suspected plants to be sampled by UCCE Rice Advisors, to prevent the movement of weedy rice seed. (Whitney Brim-Deforest and Luis Espino). The California Citrus Clonal Protection Program (CCPP) performs research and extension on topics related to citrus pathology. It also provides a safe mechanism to test, and introduce citrus varieties from any citrus-growing area of the world for research, variety improvement, or direct use by industry or citrus enthusiasts (Georgios Vidalakis).  One project works with the Napa County Agricultural Commissioner to optimize the detection program for vine mealybug on 48,000 acres (Monica Cooper and Matthew Daugherty). Research was conducted on the effects of crop rotation for disease management on southern blight in Colusa County where the disease has increased in recent years and results were shared through reports and presentations (Amber Vinchesi).

UCCE scientists also identify treatment practices and pest management strategies through research and extend them. One collaborative research project focused on assessing the factors leading to canker disease in table grape vines, in an effort to develop a disease management program and support the long-term productivity and profitability of vineyards grown in the Coachella Valley. The scientist demonstrated that the risk of infection is reduced when old stumps are removed and vines are sprayed with fungicides after pruning (Carmen Gispert). Through a project in Kern County, Pest Control Advisors (PCAs) were able to participate in projects on using mating disruption to reduce navel orangeworm infestations (David Haviland). One scientist partnered with a professor of wildland soils at Humboldt State University to analyze the effectiveness of three organic herbicides, mowing and digging as organic control options for milk thistle (Jeffrey Stackhouse).

UCCE researchers identify best practices for applying pesticides. For example, best management practices were identified for spraying pesticides to control for navel orangeworm in orchard crops.  Researchers tested impacts of weather, spray volume and droplet size. Information was extended to growers and PCAs through in-person and online training, talks, and publications (Franz Niederholzer).

UC ANR scientists work on a variety of strategies to help growers reduce yield losses. In response to injury and yield reductions after applications of Roundup to a variety of alfalfa called Roundup Ready alfalfa within the intermountain region, researchers investigated the reason for crop injury, and agronomic practices to reduce the risk of yield losses (Thomas Getts, Rob Wilson and Giuliano Galdi). Farm advisors are identifying processing tomato plants infected with Fusarium Race- 3 and providing information about the availability of Fusarium Race- 3 resistant varieties of tomatoes (Zheng Wang). Since 2015, the rice industry has been experiencing armyworm outbreaks. One program conducts research and an outreach campaign to educate growers about monitoring and managing armyworms, through a newsletter, popular articles, and blog posts (Luis Espino). A statewide team is investigating walnut blight management to understand the disease, breed blight resistant varieties, and test new treatments to manage the disease (Luke Milliron). In response to unacceptable levels of damage in tomatoes in 2018 from consperse stink bug, a scientist identified overwintering sites, evaluated pheromone-bated traps for early detection of this pest, and developed reliable control strategies (Thomas Turini). A plant pathology laboratory at the UC West Side Research and Extension Center rapidly diagnoses production issues such as sites infested with soil-borne pathogens and provide answers. For example, late blight in tomatoes was diagnosed in 2019, in Fresno county and an effective treatment was suggested (Thomas Turini). UCCE scientists also provide diagnostic services to rice growers to confirm herbicide resistance in rice fields. To date, 50% of the rice fields in California have submitted samples, and the scientists use the findings to provide IPM recommendations to the growers to manage weeds (Kassim Al-Khatib).

As a result of UC ANR research, outreach, and education, participants learned and adopted practices that led to increased agriculture efficiency and profitability. Outcomes with specific measured indicators follow.

**Outcomes**

**Participants adopted prevention and detection practices for invasive and endemic pests and diseases.**

* As a result of the sample collection protocol, growers have changed their behavior by informing scientists of an infestation, which led to the rice team identifying two additional types of weedy rice. The scientists now have a more accurate count of the number of acres infected. This understanding will help researchers determine the characteristics of each population and how to treat it. This is important information because weedy rice could reduce rice yields by as much as 70%. (Whitney Brim-Deforest and Luis Espino)
* During 2019, 3,325 users ordered 75,339 buds from 295 different citrus varieties that are typically not commercially produced in California. This is a 950% increase in the use of pathogen-tested citrus propagative materials since 2013, reducing the risk of people smuggling desirable citrus varieties into California. (Georgios Vidalakis)
* From the 23 new citrus varieties that completed therapy and testing during 2019, nine varieties were introduced by large California citrus producers.  Thousands of agricultural and agricultural industries supporting jobs could be maintained or created in the next few years as these varieties are propagated, grown in the field, come to production, and move to the market for consumption. (Georgios Vidalakis)

**Participants adopted recommended treatment and management practices for invasive and endemic pests and diseases.**

* A field assessment of the vineyard grower’s practices conducted in 2018 and 2019 showed that currently 100% of the growers remove the stumps before replanting and 75% spray a fungicide after pruning. If those science-based practices continue to be implemented it will help extend the productive life of the vineyards. (Carmen Gispert)
* There was a 25% increase in the percentage of PCAs in the San Joaquin Valley using mating disruption to reduce navel orangeworm infestations. Acreage in southern San Joaquin Valley using mating disruption increased from 16% to 39%, and from 6% to 37% in the northern San Joaquin Valley. These growers who represent nearly 420,000 acres of almonds, valued at $2.6 billion annually, benefit from reduced crop loss and thus increased profit. (David Haviland)
* Work on organic control options has reduced costs for approximately 3,000 acres of milk thistle treatment and has changed landowner perceptions on appropriate and practical treatment of coyote brush from popular mechanical treatment ($350-$1150/acre) on private ownerships to fire ($5-$22/acre) and herbicide ($65-$144/acre) treatments. (Jeffery Stackhouse)
* Results from the southern blight project contributed to knowledge of the effects of rotational crops on southern blight in the soil. Grower cooperators with southern blight issues were observed applying science-based practices such as avoiding rotations with sunflower, vineseed, and beans, as these are susceptible southern blight hosts. (Amber Vinchesi)

**Participants adopted strategies to maintain yields and reduce crop losses.**

* Results from the Roundup Ready Alfalfa trials generated information on the maximum crop height at time of Roundup application to reduce the risk of crop injury followed by frost. In conversations with extension participant growers, approximately 50% of them were able to utilize this information to prevent yield loss in the 2019 growing season. (Thomas Getts, Rob Wilson and Giuliano Galdi)
* More growers have selected Fusarium Race 3 resistant cultivars since 2018.  The Processing Tomato Advisory Board data indicates that more Race 3 resistant tomato varieties are available on the market, constituting an increased planting acreage and harvest tonnage. (Zheng Wang)
* Clientele who had heavy walnut blight infestations in the past worked with the farm advisor and adopted a recommended management program to improve their strategy for the next season, which will reduce the negative economic impact of crop loss. (Luke Milliron)
* The late blight was treated using UCCE recommendations and did not become an issue. In the event that it would go untreated under the wet conditions of the past spring, it could have caused complete loss of that 155-acre field resulting in $700,000 in losses and perhaps more in the event it were to spread to other fields. (Thomas Turini)

**Change in condition: Money saved.**

* The mealybug detection program results in an annual cost savings of $25,000 to the county, which can be redirected to other regional practices to benefit growers. (Monica Cooper, Matthew Daugherty)
* 100% of the rice growers who received UC weed science program recommendations through the herbicide screening process, adopted them. As a result they have reduced their herbicide input costs by 25%. (Kassim Al-Khatib)
* PCAs have witnessed growers driving slower and using larger spray volumes, a practice consistent with the outcomes derived from navel orangeworm spray research. Assuming that half the almond acres in Colusa, Sutter, and Yuba Counties were treated at 200 gallons per acre, the 0.5% reduction in crop loss would return value (gross) of just over one million dollars to growers. (Franz Niederholzer)
* The $2,000/acre stink bug damage reported to late-season processing tomatoes in 2018 was not suffered in 2019. Early detection of high-risk sites and grower practice alterations played a role, along with climatic conditions in the success experienced in 2019. (Thomas Turini)
* Effective insecticides for armyworm control were used in more than 40,000 acres in 2019, resulting in armyworm control, avoiding yield losses that can be as high as 20%, and resulting in economic benefits for participating growers. The availability of these insecticides could replace broad spectrum insecticides that are not effective, resulting in cost savings and environmental benefits for growers. (Luis Espino)

These measured outcomes can create, improve, and enrich the state’s ability to prevent, control, and mitigate pests and diseases and create new opportunities in economic sustainability. For example, using mating disruption to reduce navel orangeworm increased the crop value in almonds by more than $250 per acre, which is more than twice the cost of using the technique. In these ways, UC ANR contributes to increased agriculture efficiency and profitability and the public value of promoting economic prosperity in California.