AGENDA

California Avocado Commission
Production Research Committee Meeting

Meeting Information

Date: Wednesday, January 29, 2025
Time: 9:00 a.m.
Location: Hybrid Meeting

Physical Meeting Location:
University of California Cooperative Extension Ventura County
669 County Square Drive, Suite 100
Ventura, CA 93003

Web Conference URL:
https://californiaavocado.zoom.us/j/5375836823?pwd=aURBZ3BEL29tclBRS1ZRY3QrMkhZQT09&omn=88253246202

Conference Call Number: (669) 900-6833
Meeting ID: 537 583 6823
Passcode: 348652

Meeting materials will be posted online at least 24 hours prior to the meeting at:
https://www.californiaavocadogrowers.com/commission/meeting-agendas-minutes

Committee Member Attendance

As of Tuesday, January 21, 2025, the following individuals have advised the Commission they will participate in this meeting:

- **Danny Klittich,** ***PRC Chair***
- **Victor Araiza**
- **Allisen Carmichael**
- **Jim Davis**
- **Consuelo Fernandez**
- **Leo McGuire**
- **Daryn Miller**

- **Ryan Rochefort**

Time	Item
9:00 a.m.	**1. Call to Order** a. Roll Call/Quorum
9:05 a.m.	**2. Opportunity for Public Comment** Any person may address the Committee at this time on any subject within the jurisdiction of the California Avocado Commission.
9:10 a.m.	**3. Approval of Minutes** a. Consider approval of Production Research Committee Meeting Minutes of October 29, 2024
9:15 a.m.	**4. Research Program Director's Report**
9:20 a.m.	**5. Discussion Items** **a.** PhD research project ideas from FFAR Fellow Jesse Landesman
10:00 a.m.	**6. Action Items** **a.** Consider concept proposals submitted in response to September 2024 request for concept proposals.
12:00 p.m.	**7. Adjourn Meeting**

Disclosures

The times listed for each agenda item are estimated and subject to change. It is possible that some of the agenda items may not be able to be discussed prior to adjournment. Consequently, those items will be rescheduled to appear on a subsequent agenda. All meetings of the California Avocado Commission are open to the public and subject to the Bagley-Keene Open Meeting Act.

All agenda items are subject to discussion and possible action. For more information, or to make a request regarding a disability-related modification or accommodation for the meeting, please contact April Aymami at 949-341-1955, California Avocado Commission, 12 Mauchly, Suite L, Irvine, CA 92618, or via email at aaymami@avocado.org. Requests for disability-related modification or accommodation for the meeting should be made at least 48 hours prior to the meeting time. For individuals with sensory disabilities, this document is available in Braille, large print, audiocassette or computer disk. This meeting schedule notice and agenda is available on the internet at https://www.californiaavocadogrowers.com/commission/meeting-agendas-minutes and http://it.cdfa.ca.gov/igov/postings/detail.aspx?type=Notices.

If you have questions on the above agenda, please contact Tim Spann at tim@spannag.org or 423-609-3451.

Summary Definition of Conflict of Interest

It is each member's and alternate's responsibility to determine whether they have a conflict of interest and whether they should excuse themselves from a particular discussion or vote during a meeting. To assist you in this evaluation, the following ***Summary Definition of Conflict of Interest*** may be helpful.

A Commission *member or employee* has a conflict of interest in a decision of the Commission if it is reasonably foreseeable that the decision will have a material effect, financial or otherwise, on the member or employee or a member of his or her immediate family that is distinguishable from its effect on all persons subject to the Commission's jurisdiction.

No Commission member or employee shall make, or participate in making, any decision in which he or she knows or should know he or she has a conflict of interest.

No Commission member or employee shall, in any way, use his or her position to influence any decision in which he or she knows or should know he or she has a conflict of interest.

Loren Garner, Cal Poly SLO

Concept Proposal for Research at the San Luis Obispo Rootstock Trial Site (2025-2027)

Background

In 2019/2020, a collaboration began between Cal Poly, UCR, and the CAC, resulting in the establishment of a rootstock trial site on Cal Poly's campus in San Luis Obispo. This is the northern-most site in the statewide rootstock trial currently being conducted by the CAC and UCR. With financial and in-kind support from the CAC, members of the avocado industry, and Cal Poly, an avocado orchard was established at a site on campus with a documented and recent history of *Phytophthora* root rot (PRR). Trees of 'Hass' avocado grafted on 'Dusa', 'PP35, 'PP40', or 'PP45' were transplanted at the Cal Poly site on 24 June 2020 using a randomized complete block design with 10 replications of 8-10 trees per rootstock treatment in 3 blocks for a total of 384 trees, which are planted on berms at a 15' x 20' tree spacing.

In keeping with the protocols established for the statewide rootstock trial, all trees were measured and their health assessed 2 months after transplanting (August 2020) and during flushing in spring (March/April 2021-24), summer (July 2021-24), and fall (October 2021-2024), and harvest data was collected in 2023 and 2024. Our work to date has resulted in several presentations (at grower meetings and scientific conferences), contributions to all intermittent and annual reports required by me and/or Patty Manosalva to meet CAC milestones, one Master's thesis, and numerous undergraduate senior projects and class projects. Since planting, funding to support this research and maintain the orchard plot has come from ~$85K from a grant I had from the Agricultural Research Institute (end date June 31, 2023) and from the California Avocado Commission (funding cycle November 2023 through October 2025).

Concept Synopsis for 2025-2027

If approved for funding for 2025-2027, I propose to continue to maintain the orchard plot and collect and analyze the data required for the multi-site rootstock study and to build on this long-term, joint investment by investigating possible rootstock effects on nutrient requirements **(priority topic 5b)** and the effects of mulch on both frost risk **(priority topic 10)** and soil health **(priority topic 6a)**. Additionally, by continuing to keep the orchard plot well-maintained, this research plot could be utilized by other PIs as a northern site for any pest surveys and/or potential biocontrol releases that CAC may fund in other **priority topics (e.g. 25, 28-30, and/or 39)**. All studies and data collection will be conducted at the rootstock trial plot at Cal Poly and will be overseen by a Master's student to be recruited for this purpose. That student will oversee undergraduate research assistants in data collection and entry and will work with me and Andrew Schaffner (Professor, Cal Poly Statistics Department) to analyze the data and to continue to prepare reports for the CAC and UCR and to co-author presentations and manuscripts for dissemination to growers and the wider scientific community. Additionally, the Master's student can work with any CAC-funded PIs to coordinate and/or conduct on-site pest surveys and/or biocontrol releases.

Objectives for 2025-2027

1. **Continue to collect and analyze tree growth, health, and yield data for the multi-site rootstock study**
   Data to track tree growth, health, and productivity will be collected during the spring (2026, 2027), summer (2026, 2027), and fall (2026, 2027) flushes, and during harvest (2026, 2027). Data collection will include tree height, trunk diameter, canopy volume, yield, and rating salinity damage, heat damage, vegetative flush and bloom.
2. **Identify possible rootstock effects on nutrient requirements**
   Leaf samples will be collected from all 40 replications (August 2026, 2027) **for laboratory analysis** to determine any treatment (rootstock) effects on leaf nutrient concentrations.
3. **Assess the effects of mulch on soil health and orchard temperature**
   The trees are planted on steep berms, which coupled with wind, has resulted in a limited leaf litter accumulation under and between tree canopies. This location is therefore ideal to study the effects of adding wood mulch on orchard soil health and temperature. Mulch will be added to the tops of the berms and changes/differences in soil makeup/health and soil and air temperature will be monitored and assessed.
4. **Continue to maintain the orchard plot to provide a well-maintained northern growing region study site for CAC-funded pest surveys and/or potential biocontrol releases**
   Cal Poly's Plant Sciences Department has a long and successful history of collaborating with outside research entities to serve as a study site to monitor agricultural pests and for biocontrol releases. Our educational mission and fully functioning farm make us uniquely suited to such collaborations.

Total estimated 2-year cost **(2025-2027): $74, 865**

Integrating Chemical and Cultural Practices for Bot Canker Control in Avocado

Priority Topic

Avocado Branch Canker, a significant disease impacting California avocado production, caused by a complex of fungal pathogens, primarily *Neofusicucum* and *Botryosphaeria* species.

Concept Synopsis

Avocado branch canker is a devastating fungal disease that affects avocado trees worldwide. Caused by various species within the *Botryosphaeriaceae* family, this disease can lead to significant yield losses and tree mortality. The disease typically manifests as cankers on branches and trunks, which can girdle and kill infected limbs. As the disease progresses, it can cause leaf drop, dieback, and reduced fruit production. The fungi that cause avocado branch canker can enter the tree through wounds caused by pruning, mechanical damage, or insect infestations. Once inside the tree, the fungi produce spores that spread to other parts of the tree and to neighboring trees. Effective management of avocado branch canker requires a combination of cultural practices and fungicide applications. Pruning infected branches and maintaining tree health through proper irrigation and fertilization can help reduce disease severity. Additionally, timely application of fungicides can protect trees from infection. This project aims to develop an integrated disease management (IDM) strategy for avocado branch canker. The approach will combine chemical control and cultural practices to minimize disease incidence and severity.

Project Objectives

1. **Fungicide Efficacy Trials:**
   - Screen a range of fungicides for efficacy against *Botryosphaeria* species in vitro and in field.
   - Determine optimal fungicide application timing and frequency.
2. **Investigate the influence of key stress factors on Bot canker development:**
   - Determine the impact of irrigation scheduling, fertilization strategies, pruning, and sunburn on disease severity.
   - Quantify the interaction between stress factors and disease incidence and determine the optimal timing and frequency of cultural practices for Bot canker management.
3. **IDM Strategy Development:**
   - Integrate the results of fungicide efficacy trials and cultural practices optimization into a comprehensive IDM strategy and develop a user-friendly guide for avocado growers to implement the IDM strategy.

Anticipated Project Duration: Two years

Estimated Total Project Cost: $157,000: PhD student Salary (Valentina Valencia Bernal) for four quarters each year: $70,000**, Total: $140,000.** Supplies: **$12,000,** Travel: **$5,000.**

Title: Using the Sample Costs of Production Budgets to Estimate Costs and Returns of Alternative Avocado Practices.

People: Karen Jetter, Economic Researcher, UC ANR; Etaferahu Takele economic farm advisor, UCCE Riverside; Ben Faber farm advisor, UCCE Ventura.

Priority topics addressed: 1. Update Sample Costs of Production budgets and 2) Evaluate why some growers consistently achieve higher yields that other growers.

Synopsis: This project will update the UC Sample Costs of Production cost studies for the Ventura and the Riverside/San Diego regions. The development of new, and the updating existing, cost studies has long been a part of UC Agriculture and Natural Resources. Using the Budget Planner software developed by UC farm advisors and economists, we will first update the existing cost studies for each region. All participants of this project have decades of experience with avocado production and crop budgeting and have previously collaborated in developing a Sample Costs of Production budget for perennial crops. Once the budgets are updated and baseline values are established, the budgets will be modified to complete the second objective of this projects: evaluating what growers with consistently higher yields are doing in their groves that can be applied by other growers. Several reasons for observing different yields have been discussed and will be explored. One difference that has already been identified by the project team is that some regions are just more agro-climatically suitable to growing avocados and would naturally have higher yields that areas less suitable. Because there are agro-climatic niches where commercial avocado production occurs in California, differences in crop yields within each region will be explored. There may be several reasons why within certain regions some growers are outperforming others. One potential explanation is that growers with higher yields have trees planted at a greater density than growers with lower yields. Alternatively, growers with higher yields may also be investing a higher input/higher output production system than growers with lower yields. These two systems are not mutually exclusive. It may be that growers who achieve higher yields are both planting at a greater density and using a higher input/higher output production system. Focus groups will be held separately with growers who have a history of higher yields and with other growers who do not within each region. The results of these focus groups will be incorporated into the updated crop budgets, and a ranging analysis completing comparing the costs and benefits of the alternative crop growing practices over a range of values for yields and crop prices. Once the comparative crop budget analysis is completed the results will be shared with growers through UCCE outreach materials, and grower meetings. At least one meeting will be held for growers via zoom where we will present the results of study. UCCE advisors will also be able to consult with individual growers on their individual costs and returns to switch to alternative crop management practices.

Project objectives: 1) update existing costs of production budgets for each growing regions; 2) meet with grower focus groups to learn about crop production practices of higher yielding growers; 3) complete comparative analysis of costs of production budgets; 4) share results with growers through publications and grower meetings.

Project duration: 1 year

Project cost: $47,000. This covers salary to prepare budgets and conduct comparative analysis, travel, focus group meetings, and outreach materials and meetings.

California Avocado Commission
Concept proposal

PIs: Peggy Mauk (Professor of Extension, UC Riverside), Carol Lovatt (Professor Emeritus, UC Riverside) and Mary Lu Arpaia (Professor of Extension, UC Riverside)

Proposed Title: Gaining a better understanding of the impact of Gibberellic Acid application to California avocado from enhancing fruit set, fruit size and delaying senescence of the mature crop

Proposed project duration: 3 years

In order to stay competitive, California growers need to improve pollination, increase fruit size and hold fruit longer. There are new efforts to improve pollination efficiency and testing alternative products (Arpaia, et. al 2024-25). An additional tool to enhance fruit size and fruit retention is the use of gibberellic acid (GA_3). GA_3 was registered for use for California avocados in 2018 for this purpose. Carol Lovatt's GA_3 research resulted in the registration of ProGibb LV Plus for use on avocado at cauliflower stage of inflorescence development (CSID) to increase yield of commercially valuable size fruit. Lovatt also found that applications made at full bloom were not as effective. Later applications in summer during exponential fruit growth were better for increasing fruit size and yield.

The proposed research is most relevant to avocado production the southern California producing areas as temperatures are higher and holding mature fruit on the tree is challenging. Further refining the timing of GA_3 treatments to increase fruit size, reduce fruit drop and delay on tree fruit coloration of the mature crop for delayed harvest is desirable.

Year 1. We propose to further refine the impacts of different application times using single tree replicates to further characterize GA_3 impact on fruit including the percent increase in fruit size, rate of fruit drop, impact on dry matter, and the length of time GA_3 treatments continue to cause mature fruit to remain green on the tree. Foliar GA_3 application times include, CSID and monthly from May through the end of July. Additionally, the impact of GA_3 on postharvest fruit quality of the mature crop and handling will be determined through detailed postharvest studies to be conducted at the UC Kearney Agricultural Center in Parlier. Lastly, we will determine the impact of later application times (August and September) on return bloom.

Field research in Year 1 will be conducted at UCR research on 6-year-old Hass avocado trees. We will also conduct trials a grower's field in Temecula as well as a site in San Luis Obispo. All treatments will be applied to the whole tree. Data collection will include estimating fruit retention and drop and final yield, measuring fruit size, return bloom and postharvest handling evaluations.

The postharvest evaluations of fruit will use fruit harvested monthly from the UC Riverside test plot starting at CSID and will continue through August. In Year 1 we will focus on the currently registered treatment. Fruit will be assessed for external fruit color at harvest and after ripening, days to eating ripe (<1.5 lbf), the response to ethylene application during ripening (compare +/- ethylene treatment), and the storage quality of the fruit (1, 3, 5 weeks of storage at 41°F).

For the northern production area of San Luis Obispo, holding fruit is not an issue, however, the impact of early- to mid-August applications on the return bloom and the impact on postharvest quality is not known. We will include selected treatments in studies in the north.

Year 2. We will repeat the most promising treatments from Year 1 to verify results both in the field and in a postharvest setting. Additionally, there are several other commercial varieties that experience color change on the tree such as 'Lamb Hass', 'GEM' and 'Luna'. In the second year of this project, we will explore the application of GA_3 at CSID and possibly later, depending on the results of Year 1, to delay fruit coloration on the tree for these varieties. We will identify growers, most likely in Ventura County, for these trials.

Year 3. We will collect data from the trials established in Year 2 to verify the increase in fruit yield and fruit size.

Budget. Budget will include salary for travel, field research and UC Kearney Ag Center recharges, and staff salary/benefits for 2 people, one for field work and another with expertise in postharvest evaluations.

California Avocado Commission
Concept proposal

PIs: Mary Lu Arpaia (Professor of Extension, UC Riverside), Peggy Mauk (Professor of Extension, UC Riverside), Ben Faber (UCCE Advisor, Ventura County)

Proposed Title: Validation of the use of flowers at the cauliflower stage for nutrient analysis to better time fertilizer applications

Proposed project duration: 3 years

Traditionally, leaf analysis is used as a tool to guide the application of nutrients to the tree. Previous research by UC Riverside (Embleton, Jones, Labanauskas) showed that collection of spring flush leaves from non-bearing shoots in the Fall of the same year were good at predicting nutritional tree status. In 2017, Campisi Pinto et al. proposed using cauliflower stage inflorescences as an alternative to fall leaf analysis. In this study, the authors showed: "nutrient concentrations of cauliflower stage inflorescences (CSI) collected in March proved better predictors of yield than inflorescences collected at full bloom (FBI) in April, fruit pedicels (FP) collected at five different stages of avocado tree phenology from the end of fruit set in June through April the following spring when mature fruit enter a second period of exponential growth, or 6-month-old spring flush leaves (LF) from nonbearing vegetative shoots collected in September (California avocado industry standard). For CSI tissue, concentrations of seven nutrients, nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg), sulfur (S), zinc (Zn), and copper (Cu) were predictive of trees producing greater than 40 kg of fruit annually." However, the authors concluded that additional work would be needed to verify this approach before suggesting that the industry switch to this method. This original research utilized plant tissue from 6 orchards with varying tree age and rootstock.

The proposed research aims to verify the 2017 published research over a 3-year period. We propose to collect tissue samples from 2 phenological stages, 6-month-old spring flush leaves (LF) and cauliflower stage inflorescences (CSI) from five groves each in San Diego, Ventura and Santa Barbara Counties. Individual trees at each site will serve as replicates (20 – 25 trees per site) so that yield data may also be collected. We may also collect samples as outlined in the 2017 trial, using 'Hass' avocado trees located on the UC, Riverside campus.

Year 1. The activities for Year 1 would include:

- January – March: Identify cooperators and quantify information such as historical yield, tree age, rootstock, tree health, water quality and soil analysis;
- March: collect CSI samples;
- September: collect LF samples;
- UC Riverside: collect samples as outlined in previous study.

Year 2. The activities for Year 2 would include:

- Collect yield data in collaboration with individual cooperators and at UC Riverside;
- Repeat activities from Year 1 for second year of data collection;
- UC Riverside plot: repeat of year 1; modify based on findings.

Year 3. The activities for Year 3 would include:

- Collection of yield data;
- Summation and analysis of data.

Budget. Budget will include salary for travel, field research recharges (UC Riverside), and staff salary/benefits for 1 person to conduct field work and interface with cooperators. There would be a significant budget annually for tissue analysis, 25 groves x 2 times of tissue sampling for field work in the counties and 20 trees at UC Riverside with 8 sampling points per tree. Some overnight travel would be required for collection of yield data.

Development and Demonstration of a Cost-effective Electrodialysis Reversal (EDR) Process for chloride removal from Avocado Irrigation Water

Haizhou Liu, PhD, PE
Department of Chemical and Environmental Engineering
University of California, Riverside

Overview. This project aims to address Item 15 in the irrigation section of the priority topic list, specifically, to pursue promising desalination technologies to help mitigate chloride in groves. Elevated chloride in irrigation water is one of the greatest threats to avocado productivity for many growers in California. The development of efficient, cost-effective on-site desalination technologies to selectively remove chloride from the irrigation water at Californian avocado groves will significantly increase the yield of avocado trees, provide reliably high-quality irrigation water, and consequently increase the profits and competitiveness of Californian avocado groves.

Synopsis. Based on a previously funded phase-one feasibility study to develop chloride mitigation technologies from irrigation water at Californian avocado groves, the project team at UC Riverside has identified electrodialysis reversal (EDR) as the most promising chloride removal technology uniquely fitted for avocado groves on-farm applications. This selection is based on a comprehensive selection criteria including chloride removal efficiency, economics and operational easiness. EDR process is estimated to incur the lowest total cost among all candidate technologies (60-80% lower cost than membrane-based and ion exchange technologies), and saves more than 70% cost than directly purchasing treated water from municipal water districts. To further pursue this promising technology platform, this phase-two project aims to develop, demonstrate and optimized a prototype EDR apparatus to removal chloride from California grove irrigation water. Specific **project objectives** include:

1. Develop the prototype EDR apparatus and conduct chloride removal studies at lab scale using source water collected from avocado groves to generate accurate data on chloride removal efficiency, water production rate, energy consumption rate and capital/maintenance cost.
2. Optimize the EDR process by evaluating different options including ion selective membranes, electrode and blending to maximize chloride removal selectivity, minimize emerging consumption and capital/operational cost.
3. Demonstrate a pilot-scale electrodialysis reversal (EDR) operation on site on a California avocado grove to remove chloride, produce low-salinity irrigation water, generate comprehensive data on total cost estimation and system performance analysis.
4. Evaluate onsite brine treatment and freshwater recovery technologies as part of the chloride removal treatment train.

Timeline and budget. The proposed project has a duration of 3 years to address all four objectives listed above. The total budget is estimated to be ~$300,000 assuming no overhead is charged by the University of California, Riverside. The budget estimate is based on the expenditure to support one graduate student and the principal investigator to work on the project, lab supplies and parts to assemble the EDR apparatus, analytical cost to analyze chloride in water samples.

Delimiting cryptic species within avocado seed moth, *Stenoma catenifer* for improved management and control of an economically important pest

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California Avocado Commission priority research area

Pest Research High Priority number 24: Identification of unknown pests that could be introduced into the U.S. that would be detrimental to the California avocado industry

Concept synopsis

The avocado seed moth, *Stenoma catenifer*, is an avocado pest of major economic importance in the Neotropics, which encompasses its native range. This pest is a significant threat to the California avocado industry, where it is not yet established. Identifying this species is challenging, as adults possess few distinguishing external morphological characteristics besides a "C" pattern of black dots on the forewings. The lack of identifying characteristics may have led to an overly broad and phylogenetically uninformative species description of *S. catenifer*, which may be better defined as a species complex.

Nucleotide sequences of the mitochondrial DNA barcoding region (cytochrome oxidase 1) that are available in publicly available databases provide preliminary but compelling evidence that cryptic species can be resolved within the current delimitation of *S. catenifer*. Based on these 32 mtDNA sequences, *S. catenifer* is comprised of six Barcode Index Numbers (BINs). Although recognition of BINs does not always indicate discrete species, they do indicate that further investigation into their species status is necessary. A phylogenetic tree based on available sequences for specimens considered to be *S. catenifer* is shown in Figure 1. The tree shows evidence for three major clades – one from French Guiana, a second from South America, and a third from Mexico and Central America. The three sequences from Mexico can be divided into two well supported lineages (likely species), and the nine from Peru can be divided into three well supported lineages (likely species). Photographs of the sequenced specimens all show the pattern of dots on the forewing that is characteristic for *S. catenifer*. Since these sequencing results are based on a small number of specimens from a limited part of the geographic range for *S. catenifer*, extensive sampling and sequencing of a much greater number of individuals throughout the range of the species, including at different elevations, is crucial. With this increased sampling, it can reasonably be expected that *S. catenifer* could be divided into more species than are shown on the tree. The primary objective of this study is therefore to sample *S. catenifer* from Mexico, Guatemala, Costa Rica, Belize, Honduras, Panama, Colombia, Venezuela, Ecuador, Peru, Brazil, Bolivia, Guyana, Argentina, Paraguay, and Uruguay, and to evaluate and delimit cryptic species from these regions based on DNA barcode sequences (including ITS, CO1, and EF1-

alpha). Following this objective, the morphology of each cryptic species will be described in detail, including images of the morphological characters most useful for separating species. Species complexes that include morphologically similar species can vary remarkably in aspects of their biology, including their host range, specificity, and behavior. Recognizing cryptic species is therefore essential not only for effective targeted pest management, but also has important implications for agriculture since each lineage may cause differing degrees of damage. The confirmation of cryptic species and the delimitation of each species within *S. catenifer* would justify a revision of current quarantine regulations.

Nucleotide sequence data potentially allows the identification of the geographic origin of a specimen. Haplotype network analysis and the identification of single nucleotide variants (SNVs) that are associated with geography are helpful for identifying the source of an invasive species. For *S. catenifer*, this data would be particularly useful for individuals from Mexico and Guatemala, since both countries are now exporting fruit into California from different areas. The DNA barcode sequences that will be generated as part of the first objective of the study can be used to examine genetic variation within each cryptic species, and this variation could pinpoint the origin of each haplotype. If *S. catenifer* is introduced into California, knowledge of geographic variation within each species would be crucial for identifying the origin of the invasion, and could inform future quarantine and pest eradication measures, as well as the development of biological control programs with natural enemies from the pest's accurately identified native range.

The objectives of this study are therefore to confirm cryptic species within *S. catenifer* using genetic data to delimit species, to provide comprehensive morphological descriptions for each species, and to associate *S. catenifer* genotypes with their geographic origin to allow the determination of the area of origin of a specimen. The resulting data would identify new pest species in the Neotropics that threaten the California avocado industry via the potential risk of invasions through commercial fruit export and improved understanding of this putative species complex would be an essential foundation for the development of biological control programs should such an effort be needed in the future.

Main project objectives

1. Evaluate cryptic species within *S. catenifer* based on DNA barcode sequences from across the range of the species. A limited number of sequences are already available. This project will generate additional sequence data and use a variety of species delimitation methods to confirm that *S. catenifer* is a species complex, and to delimit cryptic species.
2. Describe the external morphology of *S. catenifer*, including all cryptic species, to enable unequivocal identification. High-resolution images will be taken of all relevant morphological characteristics to enhance identification.
3. Examine within-species variation based on nucleotide sequence data that will include DNA barcodes and potentially other genes. This information would facilitate the identification of the geographic origin from which an interception originated.

Anticipated project duration

The project is anticipated to be conducted over a 2-year period. During the first year, specimens will be collected, their DNA will be sequenced, and the results will be analyzed. These genetic data will be used to inform morphological descriptions during the second year of the project.

Estimated project cost

ITEM	DOLLAR AMOUNT	DETAILS AND JUSTIFICATION
PERSONNEL:		
Postdoctoral fellow	$130, 000	Base salary for two years for a post-doctoral fellow to collect specimens, conduct laboratory work, analyze data, and write manuscripts
Subtotal	**$130, 000**	
FRINGE BENEFITS:		
13% of post-doctoral fellow salary during the first year	$8,450	Fringe benefits associated with post-doctoral fellow salary, in accordance with CSU policies
28% of post-doctoral fellow salary during the second year	$18,200	
Subtotal	**$26,650**	
TRAVEL:		
International travel		
Airfare	$20,000	Foreign travel for two researchers to collect *S. catenifer* throughout its range in Mexico, Central, and South America. Potential collecting locations include Mexico, Guatemala, Costa Rica, Belize, Honduras, Panama, Colombia, Venezuela, Ecuador, Peru, Brazil, Bolivia, Guyana, Argentina, Paraguay, and Uruguay.
Accommodation	$16,000	
Ground transportation	$15,000	
Gas, tolls and parking	$2,000	
Per diem / meals	$15,000	
Incidentals	$5,000	
Domestic travel	$3,000	Travel to entomological meetings to present findings
Subtotal	**$76,000***	
SUPPLIES		
Molecular laboratory supplies		Supplies necessary for extracting DNA from specimens and generating sequence data.
Capillary array cartridges	$6,000	
DNA extraction kits	$3,000	
Flowcells and kits for high throughput sequencing	$4,000	
Tips, tubes, gloves, etc	$2,000	
Imaging supplies		Supplies necessary for imaging species to provide high resolution images of relevant morphological characteristics
Mounting media, imaging software, slides, etc.	$1,000	
Insect collecting supplies		Supplies required for collecting *S. catenifer* throughout its native range
Pheromones for attracting moths	$1,200	
Traps for collecting moths	$500	
Material to remove moths from traps	$30	
Vials and ethanol to preserve moths	$250	
Shipping specimens to partner institutions	$1,000	
Subtotal	**$18,980**	
OTHER		
Page charges for publications	$8,000	Page charges for 2-3 publications resulting from this study

Subtotal	$8,000	
TOTAL COSTS	**$129,630**	

***SUBCONTRACT TO UC RIVERSIDE:** We estimate that approximately 50% (~ $38,000) of the travel funds for this project will be used by Mark Hoddle, Department of Entomology UC Riverside, to collect *Stenoma* specimens for this project.

Figure 1. Maximum likelihood tree, of *S. catenifer* mtDNA sequences (CO1) available in public databases, along with three outgroup species. BIN numbers, each indicating a putative species, are indicated next to brackets.

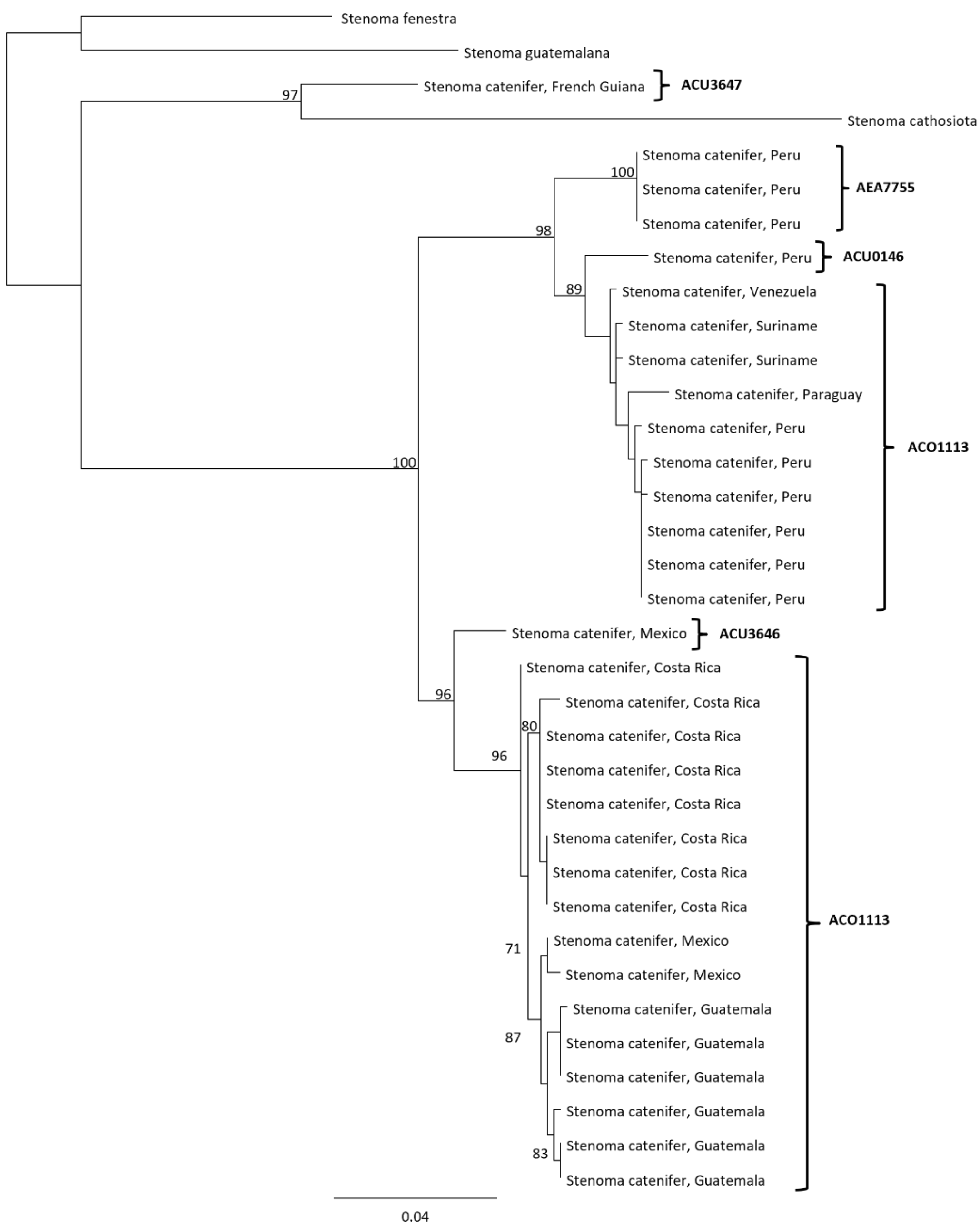

Figure 2. Map showing the known distribution of *S. catenifer*. Countries indicated in blue show localities from which samples have been sequenced, along with the number of sequenced samples from each. Countries indicated in orange show unsampled localities.

“Tree stress monitoring tools review”

Proposed researcher**:** Dr Andrew J. Krajewski, International Citrus Technologies Pty Ltd, Albany, WA 6330, Western Australia. For California Avocado Commission.

Scope of review: There is much general information concerning tree health and the adverse effects of stress on fruit tree survival and productivity. Stressors may be classified into abiotic (those induced by “non-living” agents) and biotic ones induced by living stressors, such as pests, pathogens, and by man’s activities. These stressors often interact and multiple stressors can act in concert, with unpredictable outcomes. This is complicated by the general unpredictability of climate and weather, and growers are in the position of trying to remain financially viable whilst attempting to manage a wide range of unpredictable factors affecting their operations. A possible starting point is to clearly define tree health and its effects on fitness and performance, and to define and understand effects of stress. Growers may best profit by taking control of controllable factors, and a wide range of tools exist by which four main sampling materials can be measured and assessed to prioritize issues concerning the sustained improvement of production and profitability. An important question to consider is what to sample; when and how to do so, and what management decisions to make accordingly. High production and fruit quality are no accident: both involve making the right choices over time. Decisions on management practices may be made based on the sampling and/or observation of four main areas:

1.Plant tissue (using leaf, sap, stems, twigs and branches; roots): Sampling consists of the following: Chemical analyses (macro- and micronutrients); sap analyses (macro- and micronutrients, pH, electrical conductivity, redox potential, “Brix” content); photosynthesis and carbon metabolism (e.g. starch/sugars); nitrogen metabolism (proteins/amino acids); stress metabolites (reactive oxygen species, gene activation and enzyme activities, heat-shock proteins, “stress hormones”); leaf transpiration (patterns/rates); sap flow (patterns/rates); observational studies (phenology, root studies; leaf area index, leaf cuticle “gloss”, leaf temperature vs. air temperature; dendrography); observations of agrometeorological conditions (light intensity, temperature, humidity), and of tree health and production (bearing patterns, yield, fruit size distribution, fruit quality).

2. Soil sampling: Assessments are made of the three interrelated properties of soil: **chemical** analyses (elemental composition/availability, pH and EC, redox potential), presence of chemical stressors (heavy metals, other pollutants, salinity); **physical** properties (hydrophobicity, resistance to root penetration); and **biological** activity (carbon content and C turnover, biological activity, microbial consortia promotive of “suppressive soil”).

3. Water: Chemical analyses (pH, EC, chemical composition, buffering capacity)

4. Air: presence of air “pollutants” (e.g. SO_2)

Many of the factors listed above are measurable on-site by growers, whilst others require specialised collection, storage, preparation, analysis, and to some extent, interpretation. One cannot control what one does not understand, and a review of tools available to monitor and quantify plant stress is timely and useful.

To compile review: Estimated hours **160**; over the period 1 January-30 June, 2025. Hourly rate: US$125.00 per hour; total cost = **US$20,070.00.**

PROJECT SUGGESTION: Surveys for avocado fruit feeding insect pests in Guatemala

PI: Mark Hoddle, Department of Entomology, University of California Riverside

1. Pest Research Highlight Priority Topic: This project addresses *High Priority Research Topic 24*: Imported fruit poses a risk of introducing unknown pests and diseases that could be detrimental to the California avocado industry. Avocado fruit from Guatemala was recently approved for importation into the US by USDA-APHIS and insects associated with fruit in Guatemala may pose an unknown risk to California avocado growers.

2. Concept Synopsis: At the request of the California Avocado Commission, surveys for fruit feeding pests associated with avocado fruit in Guatemala will be conducted. This project will build on previous research conducted on avocado fruit feeding moths in Guatemala from 2006-2009. However, unlike previously completed studies, fruit surveys will focus primarily on areas in Guatemala that were not intensively surveyed in earlier studies that were conducted around Antigua, Chimaltenango, Santiago Atitlán, and Escuintla over 2006-2009. One large previously unsurveyed area to the north of previously surveyed areas that is of particular interest is encompassed by moderate to high elevation avocado growing areas such as Quetzaltenango, Huehuetenango, San Marcos, Chichicastenango, San Cristóbal Verapaz, and one lower elevation production area to the west, Mazatenango. Hass avocado production within parts of this circumscribed area was “up and coming” when earlier surveys for fruit feeding pests were conducted.

3. Project Objectives: This project has one simple objective:

i. To collect as much avocado fruit as possible from six distinct geographic locations: (1) Quetzaltenango, (2) Huehuetenango, (3) San Marcos, (4) Chichicastenango, (5) San Cristóbal Verapaz, and (6) Mazatenango that have not been previously surveyed for avocado fruit pests (Fig. 1).

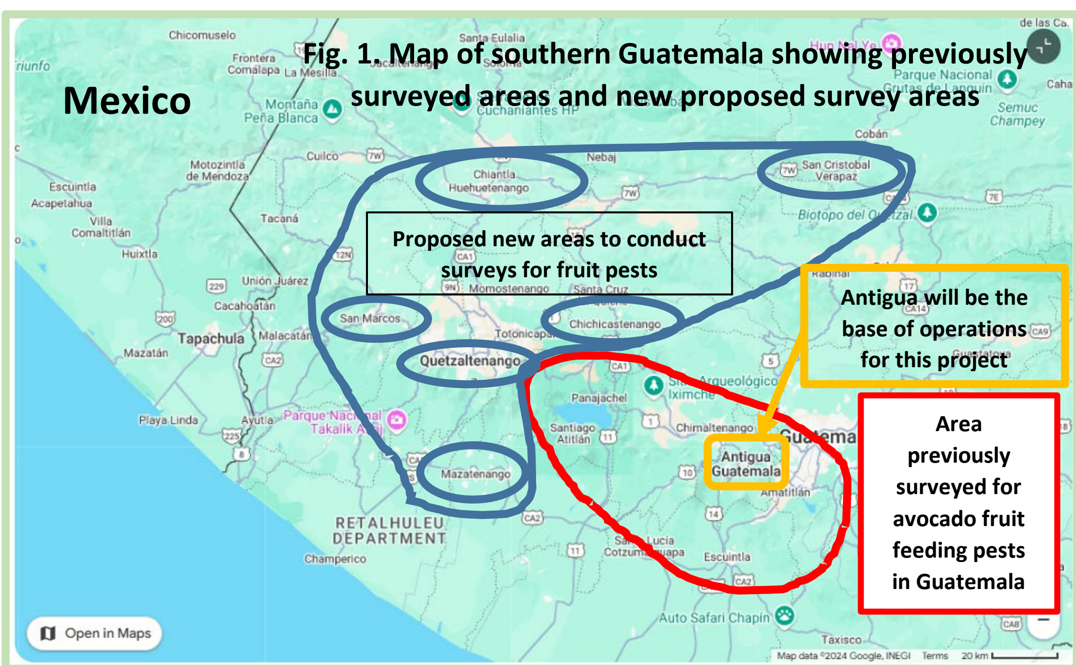

Fig. 1. Map of southern Guatemala showing previously surveyed areas and new proposed survey areas

ii. Fruit from these six areas of interested will either be collected with permission from small scale low input avocado growers, or as was done previously and with great success, purchased in large quantities from street vendors (Fig. 2A). Fruit will be placed in bugdorms (Fig. 2B) labeled by locality and date and all insects infested fruit will be reared out and preserved in 95% ethanol for future identification and DNA analyses. Fruit collections will be made in Guatemala over the “dry season,” December – June.

Fig. 2A. Hoddle holding a sack of avocado fruit purchased from roadside vendors. These fruit were held in bugdorms and insects were subsequently reared from them.

Fig. 2B. A spare bedroom in a rented house in Antigua was used as a laboratory to rear out insects from avocado fruit held in labeled bugdorms. The plastic tables, rearing bins under tables, and free standing heater/fan were all purchased in Guatemala to set up this lab.

<u>4. Anticipated Project Duration:</u> 2 years. Starting December 2025.

<u>5. Total Estimated Project Cost:</u> $510,202

<u>Personnel:</u> Funds to hire a Specialist II at 100% time for years 1 and 2 of this project are requested. Annual salary is $90,000 in year 1 and $92,700 in year 2.The Specialist is fluent in Spanish, is very familiar with Guatemala having worked with the PI on fruit pest surveys in this country previously. Specialist will assist with all aspects of field and lab work in Guatemala and will take the lead in logistics organization pre and post travel and for curating and processing all collected insects after returning from Guatemala. Total salary request = $182,700.

<u>Benefits</u>: Benefits are set at 43.7% and are estimated to be $39,330 in year 1 and $40,510 in year 2. Total benefits = $79,840.

<u>Total Salary and Benefits:</u> Year 1 = $129,330, year 2 = $133,210. Grand total requested = $262,540.

<u>Supplies:</u> Funds to purchase bugdorms (light weight collapsible insect rearing cages) for rearing insects from collected fruit are requested and estimated by to be $6,000 in year 1 and $4,000 in year 2. Total request for bugdorms = $10,000. Funds are requested to purchase fruit from roadside vendors in areas being surveyed for avocado fruit pests. $1,500 is estimated in year 1, and $1,575 for year 2. Total request for fruit purchases = $3,075. Field supplies (i.e., vials, note books, ethanol, flagging tape, indelible markers, Stenoma pheromone, heaters and fans to moderate temperature in the insect rearing "labs" (i.e., the spare bedrooms) is estimated at $2,200 in year 1 and $2,310 in year 2 for a grand total of $4,510 for both years of this project.

<u>Total Supply Costs:</u> Year 1 estimated at $9,700, year 2 at $7,885 for a grand total of $17,585 for both years of this project.

<u>Publications:</u> One publication in a peer reviewed entomological journal is anticipated in year 1 at $3,800 and year 2 at $3,990. Total publication costs for two peer reviewed articles on the results of fruit surveys is estimated at $7,790.

<u>Travel:</u>

<u>Airfares and excess luggage costs:</u> Round trip airline tickets, LAX to Guatemala City are estimated at $800 per person. Cost of tickets for two people in year 1 is estimated at $1,600 and in year 2 at $1,648. Excess baggage to move all necessary materials from California to Guatemala is estimated at $120/bag and up to four extra suitcases per person are likely to be needed. Cost is estimated at $960 in year 1 and $989 in year 2 for a total of $1,949 for both years of this project.

<u>Accommodation:</u> This project will be based in Antigua, a relatively safe city in Guatemala and one that is popular with foreigners. Consequently, accommodation in this city is expensive. An Air BnB search for a 4 bedroom house (spare bedrooms are needed as labs for setting up rearing cages [see Fig. 2B above]) in Antigua in a secure guarded compound (24 hr security) returned a monthly rental estimate of $5,500. For six months in year 1, rental accommodations are estimated at $33,000 and in year 2 at $33,900. Total rental estimates for year 1 and year 2 are estimated at $66,990.

Because the proposed new survey areas are long distances from Antigua (See map, Fig. 1) it will be necessary to rent hotel rooms/Air BnB outside of Antigua for multiple multi-day excursions into areas where fruit will be collected. Decent and secure accommodation in these towns can be expensive, and may require stays within private and secure residences. Estimated cost per night of overnight stays is estimated at $120/night, with 10 nights per month for each of 6 months being required to achieve survey goals. Total cost of hotel stays outside of Antigua is estimated at $7,200 in year 1 and $7,416 in year 2. Total hotel costs for years 1 and 2 are estimated at $14,616.

<u>Incidentals:</u> The Federal Govt. daily incidentals and expenses cost for areas in Guatemala outside of Guatemala City are set at $80/day/person. Total incidentals/meals costs for two people for 6 months is estimated at $26,880 in year 1 and $27,686 in year 2 for a grand total of $54,566 for both years of this project.

<u>Transportation:</u> Overland travel in Guatemala is difficult. Roads are often in poor condition (the exceptions are toll roads which can be expensive to travel on) and drivers are outrageously dangerous. Therefore to accommodate the demands of bad roads, especially in rural areas where avocados are grown a 4WD SUV will be needed to get to sites and to have "secure" storage for purchased fruit. Vehicle rental and insurance costs are very high in Guatemala because of risk of theft and accidents. The best estimate for a mid-size SUV hired at Guatemala City International Airport with full insurance is

$200/day. Total rental cost for 6 months for year 1 of this project will be $33,600 and in year 2 the cost is estimated at $34,608. Total vehicle rental for both years of this project is estimated at $68,208.

Gas in Guatemala is expensive and a lot of driving is anticipated to get to field sites each month of this project. Total gas cost is estimated at $450/month and will cost $2,700 in year 1 and $2,835 in year 2 for a total cost of $5,535 for both years of this project.

Whenever possible toll roads will be taken in and out of major cities. Toll roads tend to be in reasonable condition and are regularly patrolled by police which reduces risks to drivers. Additionally, parking of vehicles on streets is very risky and secure 24 hr parking areas are needed to park vehicles overnight, especially when staying in hotels or even when visiting small towns to buy fruit during the day. Cost of tolls and secure parking in year 1 is estimated at $500 and in year 2 at $525. Total cost of tolls and secure parking for year 1 and 2 of this project is estimated at $1,025.

Professional Meeting: Funds are requested to attend one professional entomology conference in years 1 and 2 of this project to present results of field surveys. Cost of meeting attendance (registration, flights, hotel, meals) is estimated at $3,000 in year 1 and $3,150 in year two for a grand total of $6,150.

Total Travel Costs: Six months in Year 1 = $109,440, six months in year 2 = $112,847. Grand total for 12 months of travel in Guatemala spread over 2 years = $222,287.

Grand Totals: Total project cost in year 1 is estimated at $252,270, year 2 = $257,932, total project costs for years 1 and 2 combined = $510,202.

California Avocado Commission

PROJECT SUGGESTION: Chemical Synthesis and Field Evaluation of an Enantiopure (+)-Grandisol, the Putative Avocado Seed Weevil (*Heilipus lauri*) Aggregation Pheromone

PI: Kevin Kou, Department of Chemistry, UC Riverside

Co-PI: Mark Hoddle, Department of Entomology, UC Riverside

1. Pest Research High Priority Topic: *Risk of importing Heilipus weevil-infested avocadoes that could be detrimental to the California avocado industry.*

2. Concept Synopsis: The aggregation pheromone of the avocado seed weevil, *Heilipus lauri* has been identified from a previously supported CAC project. This complex molecule is grandisol and simple syntheses result in mixtures of several different forms (i.e., enantiomers) of this molecule. Unfortunately, field evaluations of these impure mixtures were not attractive to weevils in heavily infested Hass orchards In México. This finding has led us to conclude that weevils may only respond to the pure biologically-active form of grandisol and the impurities when present do not attract weevils. Despite over thirty synthetic strategies reported for the preparation of grandisol, most yield a mixture of biologically-active and inactive enantiomers, while methods targeting a single enantiomer produce impractical milligram quantities of the pheromone.[1,2] We propose developing a concise synthesis approach to access significant quantities of bioactive (+)-grandisol. The pure bioactive form of grandisol will be field tested in weevil infested Hass avocado orchards in México. If successful, this aggregation pheromone will be a very powerful tool for monitoring for weevil presence in export areas of México where this weevil is native, and Colombia where this pest is invasive. Additionally, the pheromone will be invaluable for monitoring for weevil incursions into California.

3. Project Objectives:

I. Synthesize >1 gram of (+)-grandisol starting from racemic (±)-grandisol. We will develop a kinetic resolution method using the Corey-Bakshi-Shibata reagent to separate the inactive (–)-enantiomer. This is a low-risk approach to quickly generate enough of the active pheromone for initial field studies.

II. Advance a short synthesis route to (+)-grandisol starting from readily accessible reagents isoprenol and acryloyl chloride (Figure 1). Two approaches are envisioned: one incorporates the method established in **Project Objective I**, while the other explores a novel chemical reaction to construct the pheromone's four-membered ring as a single enantiomer. The latter approach offers a 100% increase in yield, as it avoids the 50% yield loss from the kinetic resolution method, which requires removal of the inactive (–)-pheromone that accounts for half the material. Both methods are designed to be scalable for manufacturing.

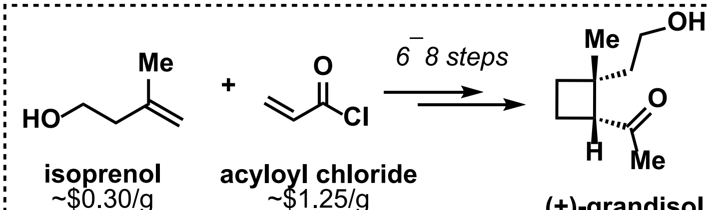

Figure 1. Proposed synthesis of bioactive (+)-grandisol

III. Conduct field studies in México to evaluate the efficacy of enantiopure (+)-grandisol in trapping *Heilipus* weevils, as previous field testing showed racemic (±)-grandisol to be ineffective.

4. Anticipated Project Duration: 2 years

5. Estimated Total Project Cost: Total $349,212

I. **Salaries and Benefits:** One post-doctoral fellow ($71,362) + employee benefits ($15,974 @ 22.4%) at 100% time in year 1 and 50% time in year 2. Post-doctoral fellow will conduct experiments, record observations and results, as well as analyze data. Total salary ($108,113) and benefits ($24,217) = $132,331. Specialist II, Entomology, to assist with field work in México at 33% time in yr 1 and 2, salary = $29,568 (yr 1) and $30,455 (yr 2) and benefits at 26% = $7,688 (yr 1) and $7,918 (yr 2). Total salary and benefits for yrs 1 & 2 = $75,629. **TOTAL SALARIES FOR PROJECT = $219,615**

II. **Supplies**: Consumable supplies and reagents ($12,000 in yr 1 and $4,000 in yr 2. Total reagents = $16,000) will support chemical synthesis experiments. Sticky cards for field trials (white, blue, green, yellow, and purple) to test attraction for weevils with pheromone = $6,000 yr 1 and $3,000 in yr 2. Total cost of sticky cards = $9,000. Field supplies for pheromone testing in México (flagging tape, vials, ethanol, note books, markers), $1,500 in yr 1 and $500 in yr 2. **TOTAL SUPPLIES FOR PROJECT = $27,000**

III. **Equipment:** UV Photoreactor ($7,000). The photoreactor provides ultraviolet (UV) irradiation for photochemical experiments and synthesis of grandisol and this equipment safely encloses and isolates reactive UV radicals. **TOTAL EQUIPMENT COST = $7,000**

IV. **Analytical Services:** Analytical Chemistry Instrumental Facilities needed for confirming and characterizing chemical intermediates and products synthesized. Estiamated cost is $5,000 in yr 1 and $2,500 in yr 2. **TOTAL ANALYTICAL SERVICES COST = $7,500**

V. **Publication Costs:** Estimated publication costs in yr 2 of project for grandisol synthesis = $3,000 and for entomological field trials with grandisol in México = $3,000. **TOTAL PUBLICATION COSTS = $6,000.**

VI. **Travel to Meetings and México for Field Work:** Cost to attend one professional O-Chem conference, PacifiChem, to present results of grandisol synthesis work = $3,000. Travel to one professional entomology meeting to present results of field work in México = $3,000. Return air flights from LAX to México City for 2 people at $600 round trip = $1,200 in yr 1 and $1,236 in yr 2, total air flights =$2,436. Air BnB, three bedroom house in Malinalco at $250/night for 56 nights (i.e., 8 weeks) = $14,000 in yr 1 and $14,420 in yr 2, total accommodation = $28,420. Meals and incidentals for two people in Malinalco based off of the US Federal rate for México City = $122/day. Malinalco is close to MX City and estimated at $80/day per person for 56 days = $8,960 for yr 1 and $9,229 in yr 2, total for yr 1 and 2 = $18,189. Rental car to get to field sites in and around Malinalco with full insurance estimated at $150/day. For 56 days rental car cost = $8,400 in yr 1 and $8,652 in yr 2, total rental car cost = $17,052. **TOTAL TRAVEL COSTS FOR YR 1 AND 2 = $72,097.**

VII. **Contract with Cooperators in México:** We have previously conducted field work on *Heilipus* weevils in México with Dr. Armando Martínez-Equihua, a professor in entomology at the post-graduate college in Texcoco México. This has been an excellent arrangement. Dr. Martínez-Equihua is a preeminent avocado pest researcher in México whose previous assistance has been invaluable in procuring access to field sites for medium-term field studies on *Heilipus*. Assistance with Mexican cooperators for this project will be essential if it is to be successful. To facilitate this cooperation, Dr. Martínez-Equihua will require $5,000 in yr 1 and yr 2 for a **total of $10,000** to help with negotiations with Comite Estatal de Sanidad Vegetal del Estado de México, in Malinalco and Coatepec-Harinas, México to locate and access field sites and to get permission from orchard owners, to assist with on the ground logistics, and to participate in planning and execution of field trials.

References Cited: 1) dos Santos, M. K. *et al. Mini-Rev. Org. Chem.* **2021**, *18*, 690.

California Avocado Commission

2) Bartlett, W. R. *et al. Synthesis* **2022**, *54*, 3209.

California Avocado Commission
PROJECT PLAN / RESEARCH GRANT
REQUEST FOR PROPOSAL

Request for Proposal: Please use the spaces below to include important specific details for your project:

Duration of Project: **Start Date: 2025__________ - End Date: 2026________**

Project Leader: Jorge Ferreira
Mailing Address: 450 W Big Springs Rd., Riverside, CA 92507
Phone: 951-369-4832
E-mail: Jorge.Ferreira@usda.gov

Co-PIs or Collaborators

Co-PI
Name: Devinder Sandhu, Research Plant Geneticist,
Institution: USDA-ARS, US Salinity Laboratory
Email: Devinder.Sandhu@usda.gov

Project Title: Understanding genetic, ionic, and Physiological Bases of Salt Tolerance in Avocado Rootstocks

Water is the most limiting factor for any crop cultivated in semiarid regions. Avocado-growing regions rely on a combination of Colorado River water, groundwater, and local reservoirs (Spann, 2024). Avocado is one of the most salt-sensitive crops in the world. Also, Colorado River water was reported to have 700 mg/L of total dissolved solids (TDS) in 2017 (Board), which is equivalent to 1.0 dS/m. Although avocados may tolerate this salinity without visual symptoms, fruit yield losses were reported when soil-paste electrical conductivity (EC_e) was above 0.6 dS/m (Oster et al., 2007). A USSL-UCR study on 13 avocado rootstocks found that, after 23 months of irrigation at EC_w=1.5 dS/m, rootstocks with high Na and Cl accumulation had 100% mortality, while rootstocks that restricted salt transport survived (Celis et al., 2018). Subsequent research in Israel with two 'Hass' avocado rootstocks at EC_e=0.73 dS/m and Na and Cl concentrations of 22.3 and 17.6 mg/L confirmed these results (Lazare et al., 2021). With the reduced availability of low-salinity groundwater, the scarce precipitation in Southern California, the increase in avocado cultivation, and the increasing salinity of Colorado River water and groundwater, the use of reclaimed water seems inevitable (Harkness et al., 2023). Moreover, California's push to expand crop irrigation with treated tertiary-treated municipal wastewater—with a typical salinity of 1.1 dS/m (825 mg/L TDS)—underscores the urgent need for salt-tolerant avocado rootstocks.

Plants employ several mechanisms to cope with salinity stress and toxic ions, which include uptake or exclusion by roots, sequestration in vacuoles, root-to-shoot transport regulation, accumulation of compatible solutes, and tissue tolerance (Munns and Tester, 2008; Sandhu and Kaundal, 2018). Hence, understanding the roles of different component traits of plant salt tolerance mechanisms is critical.

Our salinity research facility is well-equipped to evaluate avocado rootstocks for salinity tolerance and support breeding programs to develop salt-tolerant varieties. We have extensive experience with fruit and nut crops, including almonds, peaches, and grapes. For the past eight years, we have received consistent funding from the Almond Board of California to advance rootstock and variety development for saline-affected regions. During this period, we assessed 16 commercial rootstocks and over 120 selections from USDA-ARS and UC Davis breeding programs. We demonstrated a significant variation for different components in diverse almond- rootstock genotypes. Our findings highlighted that Na, and to a lesser extent, Cl are the most critical toxic ion for almond rootstocks (Sandhu et al., 2020). Top-performing rootstocks under salinity had the least amount of tissue accumulation of Na and Cl, suggesting that ion exclusion may be the main component trait of the salt tolerance mechanism in almonds. Furthermore, the expression analysis of salt tolerance genes revealed that treatments where Na and Cl were the main ions in irrigation water led to the induction of most genes, suggesting the importance of both Cl and Na toxicities during salt stress in almonds.

Our previous studies on almond rootstocks provided a detailed analysis of the importance of different component traits and this knowledge can be transferred to avocado rootstocks. Using this approach new rootstocks can be quickly developed for vigor and tolerance under salinity.

Objectives:

1. Evaluate 50 diverse avocado rootstocks from nurseries and the UC Riverside collection for salinity tolerance under mixed-salt conditions.
2. Characterize physiological and biochemical markers associated with salt tolerance.
3. Identify genetic networks regulating salinity tolerance in avocado rootstocks.

The ***rationale*** of the study is that if we identify salt tolerant rootstocks and characterize the genetic mechanisms playing important roles in salt tolerance, California avocado growers may be able to increase fruit yield with waters considered of low-quality for avocado cultivation. Our approach to utilize genetic and physiological parameters to identify genes and molecular markers involved in salt tolerance will fast-forward the development of elite avocado germplasms, increasing the profitability for California growers. The knowledge created in this project will facilitate avocado research worldwide in light of global climate changes and reduced freshwater availability.

Assessing the role of plant immune activators to improve avocado resilience to salinity and major avocado diseases under greenhouse and field conditions

Principal Investigator: Dr. Patricia Manosalva
Project duration: Three years. April 1st 2025 - March 31st 2028.
CAC Production Research Priorities 15, 31, & 34: Salinity management (15), other active ingredients to control phytophthora root rot (PRR) management (31), and management of avocado branch canker (34).

PROJECT SYNOPSIS

Water stress including heat, drought, and salinity will continue to increase due to climate change events and will exacerbate diseases such as Avocado Branch Canker (ABC) and Phytophthora root rot (PRR) increasing tree mortality and reducing the avocado production in California (CA). Currently, limited chemical control, resistant cultivars, or cultural practices are available to control ABC in avocado. Although, ABC, is considered a stress-related disease, it is critical to identify control methods for this disease including use of resistant cultivars, enhancing plant health & immunity, fungicides, and cultural practices because the negative effects of climate change and the high cost of water will continue posing water stress in CA avocado orchards. There are several chemistries registered to control avocado PRR, however, the overuse and the capacity of the Phytophthora genus to acquired resistance to some of these chemistries has been reported. The use of biostimulants and plant immune activators capable of helping avocado to cope with abiotic (i.e., salinity, drought, etc) and biotic (i.e., ABC, PRR, etc) stressors has not been tested in CA. The plant hormone, salicylic acid (SA), is a key signal molecule shown to induce local and systemic resistance to several pathogens including *Phytophthora spp*[1]. In addition, exogenous application of SA or SA inducers enhances tolerance to salt, drought, heat, cold, and heavy metals in several crops[2]. Potassium silicate is a biostimulant that help plants to cope with abiotic and biotic stresses[3]. Acibenzolar-*S*-methyl (Actigard)[4] and ascaroside 18 (ascr#18)[5] are plant immune activators that prime SA responses and provide broad-spectrum resistance to different pathogens under GH and field conditions. Here, we will test the effect of potassium silicate, actigard, and ascr#18 on enhancing plant resistance to salinity, ABC, and PRR in avocado under greenhouse (GH) and field conditions.

REFERENCES

[1]Manosalva et al. 2015. Mol. Plant Microbe Interact. doi: 10.1094/MPMI-23-9-1151; [2]Yang et al. 2023. International Journal of Molecular Sciences. https://doi.org/10.3390/ijms24043388. [3]Carneiro-Carvalho, et al. 2020. Journal of Plant Disease and Protection. https://doi.org/10.1007/s41348-019-00292-y. [4]Brown et a. 2019. Plant Disease. https://doi.org/10.1094/PDIS-09-18-1597-RE. [5]Manosalva et al. 2015. Nature Communications. DOI: 10.1038/ncomms8795.

PROJECT OBJECTIVES

Obj.1. We will first test the induction of key pathogen and salinity defense response genes in commercial and UCR resistant rootstocks after potassium silicate, actigard, and asc#18 treatments to determine the best concentration, application time, and mode of application for the strongest induction without phytotoxic effects under laboratory and greenhouse conditions.

Obj.2. Conduct greenhouse efficacy trials for the immune activators to improve avocado responses to pathogen and salinity stressors alone and in combinations. We will treat clonal liners from selected commercial and UCR resistant rootstocks with the immune activators based on results from Obj.1. We will collect phenotypic & physiological data and assess the expression of key biochemical markers associated with pathogen and salinity resistance and compared those with data collected from control treatments.

Obj.3. Field test (Agua Tibia, San Diego) of the best treatments identified in greenhouse trials described in Obj.2 and assess the effect of immune activators in several rootstock/scion combinations to improve resistance to salinity, PRR, and ABC under natural disease pressure.

Estimated Budget: $216,386

Total Budget: $216,386	**Year 1**	**Year 2**	**Year 3**
Personnel			
Amber Newsome (Assistant Specialist I) @ 50% EFT + Benefits	46179	47565	48,992
Domestic Travel conduct and collect data in Agua Tibia, San Diego		2,500	2,500
General, GH, & field supplies, consumables, chemicals, and experimental clonal liners	29,100	18,500	13,250
Greenhouse fees	3000	3000	1,800

Improve *Phytophthora cinnamomi* control management by monitoring field populations for changes in fungicide sensitivity and conducting efficacy field trials

Principal Investigator: Dr. Patricia Manosalva
Co_Principal Investigator: Dr. James Adaskaveg
Project duration: Three years. April 1st 2025 - March 31st 2028.
California Avocado Commission Ag Chem Product Research, High Priority 31: Resistance management of chemical control for Phytophthora.

PROJECT SYNOPSIS

Phytophthora root rot (PRR), caused by *Phytophthora cinnamomi* (*Pc*), is one of the most devastating avocado diseases worldwide. PRR severity and incidence are exacerbated under flooding and hypoxic conditions caused by inappropriate irrigation practices and soil waterlogging conditions, which are common conditions in California (CA). PRR control methods include management practices, use of resistant rootstocks, and chemical treatments (potassium phosphite [PP], mefenoxam [Ridomil Gold], and oxathiapiprolin [Orondis]). Orondis was recently registered to control avocado PRR based on greenhouse and field efficacy trial results conducted by Manosalva and Adaskaveg teams. Growers have been relying on a resistant industry standard rootstock, Dusa, and PP for PRR control, however *Pc* isolates overcoming these practices, have been reported in CA[1,2]. A recent survey conducted by the Manosalva Lab (2022) found a large variability regarding PP sensitivity with isolates exhibiting EC_{50} values (chemical concentration to inhibit 50% of mycelia growth) from 3.57 to 763 µg/ml. Additional chemistries (ethaboxam [Elumin] , fluopicolide [Presidio], & mandipropamid [Revus]) and new UCR PRR resistant rootstocks to be released in 2025-2026, hold promise for growers, however, the effectiveness and durability of these new control methods still deserves extensive evaluation due to the great genome plasticity and adaptative capacity of *Pc* populations to local environments and controls methods[3]. We will monitor *Pc* populations by conducting an extensive survey in orchards & nurseries through CA to: i) determine their current fungicide sensitivity and ii) assess if the baselines for sensitivity to mefenoxam and orondis have been changing and if more *Pc* isolates are acquiring PP resistance. Resistance assessments for registered fungicides will be conducted alone and in mixtures to determine how pathogen sensitivities change overtime. Finally, we will continue collecting data from a fungicide efficacy field trial established in Temecula and we will establish another in Ventura. These efficacy trials will allow us to: i) test different application protocols to reduce the negative effects of PRR in tree health and productivity and ii) determine the anti-resistance rotation and mixture programs to set sustainable and durable protocols for PRR control in CA.

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1. Belisle et al. 2019. Phytopathology. DOI: 10.1094/PHYTO-09-17-0326-R.
2. Adaskaveg et al. 2024. Journal of Plant Diseases and Protection. https://doi.org/10.1007/s41348-024-00873-6.
3. Shands et al. 2024. Frontiers in Microbiology. DOI 10.3389/fmicb.2024.1341803.

PROJECT OBJECTIVES

Obj.1. Survey *Pc* populations across major CA avocado growing regions and assess their *in vitro* sensitivities to registered and new oomycota fungicides to compare those with established baseline sensitivities. Information regarding cultural practices, fungicide history applications, soil & water characteristics at each orchard surveyed will be recorded. Resistance assessments of registered products alone and in mixtures will be conducted using avocado seedlings inoculated with sensitive, insensitive, and mixed *Pc* populations under laboratory and greenhouse conditions.
Obj.2. Conduct fungicide efficacy treatments under commercial conditions to determine the best protocol to maximize chemical protection and reduce the emergence of *Pc* resistant isolates. We will continue the evaluation of several fungicides including Orondis, Presidio, Elumin, and Prophyt (PP) alone and in combinations to reduce PRR incidence and damage in plant health & productivity in our current trial of 'Hass' on Dusa rootstocks (Temecula). We will also establish a similar fungicide efficacy trial in Ventura.

TOTAL BUDGET: $324,901

Total Budget: $324,901	**Year 1**	**Year 2**	**Year 3**
Personnel			
Matthew Elvena (PhD student) @2 Academic quarters/year and summer quarter in Y3	31,843	32,942	43,724
Postdoc (Adaskaveg) @ 50% EFT	45,423	48,754	50,215
Domestic travel	12,000	12,000	12,000
Supplies	12,000	12,000	12,000

Leveraging and establishing rootstock/scion trials to determine the effect of rootstocks on improving scion's abiotic and biotic stress resilience

Principal Investigator: Dr. Patricia Manosalva
Project duration: Three years. April 1st 2025 - March 31st 2028.
Production Research Priority 7: Rootstock trials for high carbonate and salinity conditions.

Project Synopsis

Avocado production and sustainability are under threat due to water stress (i.e., salinity) which also exacerbates major infectious diseases. These stressors usually occur together and can destroy orchards if not managed properly. Each production area/orchard has their own climate, production challenges, and cultural practices; Thus, it is crucial to choose the right rootstock, which will best support the chosen scion. Genetically diverse water stress and pathogen resistant rootstocks are needed to mitigate different production challenges. CA growers are eager to use several commercial and UCR experimental rootstocks grafted to 'Hass' and other scions to diversify their orchards, address production challenges, and increase productivity. We will collect and integrate phenotypic, physiological, ionomic, and production data from several rootstock/scion combinations at 10 field trials established under different environmental, stressors, and cultural practices conditions (**Table 1**) to identify the best rootstock/scion combinations to mitigate major production challenges and aid growers in making informed decisions on the best rootstock/scion combinations to sustain productivity and competitiveness. Soil, water, leaf, and root analyses will be coupled to these large datasets to identify interactions of rootstock/scion genotypes x environment (soil and water characteristics) in order to determine vulnerabilities and adaptive combinations that farmers can use to mitigate different stressors. New commercial rootstocks are available, but their performance has not been extensively tested in CA; Thus, we will conduct greenhouse (GH) experiments to test the salinity and pathogen responses of commercial and newly identified UCR rootstocks (Mexican x Guatemalan x West Indian) exhibiting resistance to salinity, heat, and major avocado pathogens. The best UCR and commercial rootstocks based on our GH results and all field data available will be used to establish replicated trials under field extreme conditions (high salinity, carbonates, major pathogens, and heterogenous orchard soil composition).

Table 1. Description of the rootstock field trials established in California to be used in this project. Evaluation currently funded by the California Avocado Commission (CAC) & USDA-SCRI Grant.

Grower	County	Rootstock	Field conditions
Leo McGuire	Temecula/ Riverside (2 fields)	**Scion:** Hass; **Rootstock:** Dusa (T), PP35 (T), PP40 (T), PP42 (MT), and PP80(U)	EC= 0.82 dS/m, chloride= 102 mg/L, pH = 7.9, $CaCO_3$ =130 mg/L, and high PRR incidence (Orondis). Loamy sand to sandy loam.
Agua Tibia LLC, Ranch	Pala/San Diego	**Scion:** Hass, Gem, Lamb-Hass, and Reed; **Rootstock:** Dusa (T), PP35 (T) PP40 (T), Toro Canyon (T), Steddom (T), PP80 (U)	EC =2.48 dSm, chloride =259.6 mg/L, pH =8.7, $CaCO_3$ =110 mg/L, and PRR. Sandy loam.
John Lamb	Camarillo/ Ventura (2 fields)	**Scion:** Hass; **Rootstock:** PP35 (T), PP40 (T), Dusa (T), PP42 (MT), PP80 (U).	EC = 1.16 dS/m, chloride = 148 mg/L, pH = 8.7, $CaCO_3$ = 160 mg/L, No PRR. Loamy sand to silt loam.
Pete Miller	Goleta/ Santa Barbara	**Scion:** Hass; **Rootstock:** Dusa (T), PP35 (T), PP40 (T), PP45 (S), PP80 (U)	EC = 3.65 dS/m, chloride = 251 mg/L, $CaCO_3$ = 220 mg/L, and high PRR. Loam to clay soil.
Pete Miller	Goleta/ Santa Barbara	**Scion:** Hass, Gem, and Lamb-Hass. **Rootstock:** Dusa (T), PP35 (T), PP40 (T), PP80 (U)	EC =1.92 dS/m, chloride = 236 mg/L, pH = 8.3, $CaCO_3$ = 220 mg/L, and PRR incidence. Loam.
Chris Sayer, (Petty Ranch)	Ventura	**Scion:** Hass; **Rootstock:** Dusa (T), PP35 (T), PP40 (T), PP45 (S)	EC =2.3 dS/m, chloride = 92 mg/L, pH = 7.4, $CaCO_3$ = 320 mg/L (severe). No PRR incidence. Loamy sand to silt loam. High limestone.
Adna Farms	Temecula/ Riverside	**Scion:** Hass; **Rootstock:** Dusa (T), PP35 (T), PP40 (T), PP45 (S)	EC= 0.82 to 1.1 dS/m, chloride= 102 mg/L, pH = 7.9, $CaCO_3$ =130 mg/L, and high PRR incidence (Orondis). High clay composition.
Pine Tree Ranch	Ventura	**Scion:** Hass; **30 Rootstocks:** Dusa, Leola, Zerala, Steddom, Toro Canyon, Uzi, Zentmyer, Topara, PP35, PP40, PP45, PP42, PP80, 11 new UCR selections, 4 selections from SA, and two Israeli rootstocks.	EC= 0.74 to 1.1 dS/m, chloride= 35 mg/L, pH = 7.56, $CaCO_3$ =130 mg/L. No PRR. 2.7% of limestone. Alkalinity problems. Loamy sand to Loam soil.

T= Salinity Tolerant, MT = Salinity Moderate Tolerant, S = Salinity Susceptible, U = unknown, PRR = Phytophthora root rot. SA = South Africa.

Project Objectives

Obj.1. Collect and integrate phenotypic, physiological, ionimic, and production data of rootstocks grafted to 'Hass' and other scions established across major CA growing regions under different stressors including salinity, high carbonates, soil composition, and different cultural practices (**Table 1**).
Obj.2. Confirm and determine the field salinity & pathogen resistance phenotypes of highly admixed UCR rootstocks and new commercially available rootstocks, respectively, under greenhouse conditions.
Obj.3. Survey grower's orchards through CA for extreme conditions (high salinity & chloride, high carbonates, high pH, high disease pressure, different soil compositions) and establish new rootstock/scion trials with the best commercial rootstocks and UCR rootstock identified in Obj. 2 grafted to two scions based on grower's preferences.

Estimated Budget: $299,327

Total Budget: $299,327	Year 1	Year 2	Year 3
Personnel			
Amber Newsome (Assistant Specialist I) @ 50% EFT + Benefits	46179	47565	48,992
Matthew Elvena (Ph.D student)@two Summer quarters for the first two years	9087	9360	
Travel	10,000	10,000	10,000
Supplies including trees for GH Obj. 2 and field trees for Obj. 3	10,120	25,000	10,120
Soil & water analyses	2888	1368	1,368
Leaf and root Ionomic analyses (Objs. 1 &2)	8640	40,000	8640

CA Avocado Commission Concept Proposal, December 2024

- **Topic Area**: Cultural Methods
- **High Priority Topics**: (2) Updated Cost Studies (Northern Regions)
- **Project Lead**: Michael McCullough, PhD. Professor, Cal Poly Agribusiness; Senior Economist, ERA Economics (michael@eraeconomics.com; c:509.338.5003)
- **Project Team**: Tori Laird, Harry Ferdon, Duncan MacEwan (ERA Economics)

Project Deliverable

We propose to prepare two (2) economic cost of production studies for the northern growing regions (San Luis Obispo and Southern Monterey Counties). Each production budget will have a concise narrative and tabular summary of operating, establishment, regulatory, and other costs associated for producing avocados. A concise sensitivity analysis will be presented along with a limited financial/risk analysis, market narrative, and qualitative overview of ecosystem services provided by avocados.

Distinguishing Components

The following considerations apply to this work:

- University Cooperative Extension (UCCE) budgets are general and not tailored to a specific region. Under this project, we will develop two budgets that are tailored to market conditions, costs, and returns in two specific northern production regions.
- UCCE budgets do not include all faming costs, such as direct and indirect regulatory compliance costs. These costs will be gathered and quantified.
- The budgets we show will be dynamic and tailored to local conditions. This will include a reduced-form, basic analysis of avocado market (supply and demand) conditions that will be used to develop informed sensitivity analyses and risk analyses in each budget. This can be expanded under future projects, if it's determined to be of interest to the Commission.

Work Plan Overview

Our proposed workplan is as follows, and will be expanded/refined in consultation with the Commission if our concept proposal is accepted:

- Compile market and economic data that will include but is not limited to typical agricultural production costs and returns, cropping trends, water and land use, capital expenditures, ongoing regulatory costs, and other market data. Will be developed in consultation with the Commission.
- Prepare budget for each region. This will include standard production cost categories that will be refined during grower outreach meetings, including regulatory costs. Qualitative summary of ecosystem services, which can be expanded under future projects.
- Prepare basic financial analysis, risk analysis, and prepare cost of production budgets. Develop brief documentation, simple tables, and figures for report. Prepare two (2) reports.

Budget, Schedule, Other Assumptions

We will meet with the Commission to refine the final project schedule; a preliminary estimate is work completed within one year. Our estimated budget range is $30,000 - $40,000. This assumes Commission leadership in identifying regions and partners for interviews, and assumes limited meetings, presentations, and other project outreach. These additional services could be added as part of an extended project.

Weather Station Network for Avocados

Andre Biscaro, Ben Faber
UC Cooperative Extension, Ventura County

Priority topic your proposal addresses:

This project proposal addresses two topics in irrigation management: the replacement of CIMIS stations by a network of stations managed and maintained by UC ANR, and to improve the accuracy of water and nutrient applications, such as the use of the Irrigation Calculator, currently funded by the Avocado Commission. Increased numbers of stations are essential to address different microclimates and therefore improve the representativeness and accuracy of weather station's data. Once the concept is implemented and tested in Ventura County, it's expansion to other counties will be streamlined.

One paragraph concept synopsis:

A network of four weather stations will be implemented at different microclimates located in Ventura County. These stations are designed to collect reference evapotranspiration (ETo) data, an essential parameter used to improve irrigation scheduling. The stations need a well-watered grass area around it, which leads us to the main challenge of this project: identify cooperating growers who can host these stations. Therefore, this project may not come to fruition and funds will be returned to the commission if we can't identify sites to host the stations. Since there is little scientific support for the exact size of the grass area needed for reasonable data accuracy, we are proposing to address that at one of the four sites. This would be done by installing a base station in the center of a large grass area (of approximately 4 acres) and a secondary mobile station that will be placed at different distances to the edge of the grass every 3 months. The ETo data from the mobile station will be compared to the base station to assess the accuracy of readings taken from different distances to the edge of the grass. Therefore, we are proposing three stations at grass areas of 100x100ft (0.2 acre), and one at 4 acres. All stations with cooperating landowners to be identified.

A list of project objectives:

1. Establish small test network of station to gather high quality local ETo data
2. Test the required amount of grass need for station accuracy

Anticipated project duration:

Two years for the assessment of the size of the grass area needed. Five years for the other stations (ongoing costs would need to be assessed at that point).

Estimated total project cost:

$	

30,000	3 Campbell Scientific stations
18,000	1 Campbell Scientific station with mobile sensors
2,000	SRA time
2,000	miscellaneous
20,000	Grower incentive for 4 acres (optional)
52,000	Total Project Research Cost
15,000	Optional Grower Incentive/ Location Rent ($2,500 per site per year)
67,000	Total Requested Funds

Assessing irrigation management tools on avocado fruit quality and yield impacts

Principal investigator: Ali Montazar, Irrigation and Water Management Advisor, UCCE San Diego, Riverside, and Imperial Counties; email: amontazar@ucanr.edu.

Introduction. Avocado is a sub-tropical rainforest tree and therefore, careful water management is critical to ensure optimal yield and high-quality avocado fruit. This is even more important under avocado crop production systems in California due to uncertain water supplies, mandatory reductions of water use, the rising cost of water, and increasing salinity in water sources. We have conducted extensive data collection and analysis over the last three years in 12 avocado commercial sites under various environments and conditions. Through this study, seasonal crop coefficient (Kc) curves have been updated for California avocados, and several irrigation tools and technologies have been evaluated including different types of soil moisture sensors, avocado irrigation scheduling calculator, OpenET satellite tool, Tule Technologies, and Sap Flow and FloraPulse sensors. While we developed more accurate seasonal Kc values and a better understanding of the efficacy of irrigation tools as well as some evaluations on water-salinity related issues and management status in CA avocados, a second phase of the study needs to be carried out assessing the developed Kc values in regards with avocado fruit quality and yield impacts. This is a necessary phase that may provide growers with a high level of confidence to adopt the information and enhance the efficiency of water use in avocados. This new project aims to:

- Verify the developed Kc seasonal curve regarding avocado fruit quality and yield impacts.
- Assess the impact of irrigation tools and management strategies on yield and fruit quality of avocados.
- Quantify water use efficiency enhancement following improved irrigation management practices.

Research plan. The field experiment will be conducted in two avocado research sites equipped with the flux tower over a three-year period, one in Temecula and one in Escondido. The seasonal Kc curve had been already developed for these sites. Five irrigation strategies will be arranged in a Randomized Complete Block Design with six replications (six trees per irrigation strategy). The irrigation strategies will consist of (1) grower practice the entire growing season as control treatment, (2) 100% ETc, (3) 120% ETc, (4) 80% ETc, and (5) irrigation based on OpenET Ensemble data. ETc will be determined using the Kc values developed for the site and spatial CIMIS ETo data. To verify the irrigation management strategies, soil water status will be monitored within the soil profile (depths of 6-36 in.) in each treatment using three different types of soil moisture sensors. A precision irrigation system will be set up to accurately monitor and deliver irrigation water in each treatment. EM-38MK2 will be run to develop salinity maps in the experimental areas of each site. Soil salinity will be evaluated twice per year, mid-August and early May and the required leaching will be performed as needed. Monitoring plant water status will be conducted using dendrometers and microtensiometer (Florapulse) on a continuous basis along with pressure chamber readings (three times per month). In addition, the difference of canopy temperature versus air temperature recorded by fixed view-angle infrared thermometers along with aerial imagery and analysis will be used to evaluate crop water stress indices. Continuous normalized difference vegetation index (NDVI) values will be measured by Spectral Reflectance sensors. Implexx Sap Flow sensor will be utilized to measure trees transpiration as well as Leaf Porometer to monitor stomatal conductance. The agronomical performance of irrigation strategies will be also assessed during the seasons by monitoring fertilizations, foliar nutrient content and fruit yield. Avocado fruits are gradually harvested from February to April to assess yield and water productivity. To evaluate the fruit size (i.e. indicative of commercial quality), fruits are analyzed and classified into different size-classes according to their weight. The percentage of dry matter is also analyzed in five randomly selected fruits per irrigation treatment with a Near Infrared Analyzer (NIR). A robust outreach program will be developed to disseminate project findings to growers and stakeholders.

Requested Funding Amount: $225,000

Irrigation Topic 15: Chloride Removal from Irrigation Water

Preliminary Proposal for 2024 Avocado Commission RFP
Tailwater Systems
3855 Via Nona Marie Suite 205
Carmel, CA 93923
29 November 2024

Background

Rising chloride levels are damaging California's avocado groves. The chloride ion is difficult to remove and there are no "chloride removal systems" currently being marketed. Without a cost effective way to mitigate or possibly remove and sequester the chloride, many orchard managers may eventually give up, cut down the trees, and leave the marketplace.

Concept

Tailwater Systems has innovated and patented a way to do this. Our solution uses a two step method to: a) separate the chloride anion from irrigation water using a specialized ion exchange resin, and b) sequester the chloride permanently so it cannot re-enter the water supply.

Research Objectives

a. Demonstrate a pilot treatment system that will produce 2500 gallons a day of very low chloride (< 25 mg/L) water at a single grower site. Enough for approximately 50 trees
b. Quantify the short term and long term effects of chloride removal on tree and fruit health by comparing the trees treated with chloride-free water with an adjacent control sample of trees receiving normal irrigation treatment
c. Assess grower's abilities to manage the system on their own
d. Publish a report that quantifies the effect of the system on tree health, system functionality and suitability for use by growers.

Project Duration

The initial site will have the system for 12 months. The system is mobile and can be relocated to other sites for evaluation after the first site is complete.

Project Budget

Total budget for the system hardware is approximately $40,000 (cost + 10%) installed at the initial site. Operating costs during the grant include periodic checks by Tailwater, and chemical resupply.

Title: Impact of Natural Vegetation on Insect Pollinators in Agroecosystems

Principal Investigator: Carson Loudermelt graduate student, Cal Poly Pomona
Co-Principal Investigator: Dr. Hamutahl Cohen, Assistant Entomology Advisor, Ventura, UC ANR
Co-Principal Investigator: Dr. Adam Lambert, Associate Researcher, UC Santa Barbara
Co-Principal Investigator: Dr. Elizabeth Scordato, Associate Professor, Cal Poly Pomona

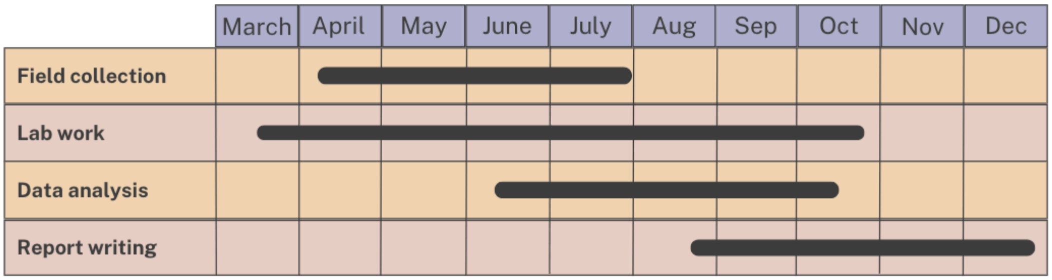
Research Problem & Project Synopsis

The demand for pollination services in agriculture frequently exceeds the supply (Mashilingi et al. 2022). This is a particular problem for the avocado industry. Avocado growers typically rely on managed honeybee populations for pollination of avocados, but the most effective pollinators of this crop are likely solitary bees, wasps, and flies. In fact, when wild pollinators are present, avocado crops can have a more than 25% increase in production (Lara-Pulido et al 2021). Furthermore, declining wild pollinator populations have been shown to adversely impact avocado yields (Biesmeijer et al., 2006). However, it is unclear which species are the most common avocado visitors and how growers can support these wild pollinator populations through management practices (Lara-Pulido et al 2021), especially in Ventura County. While avocado visitors have been identified in Mexico and Central America (Can-Alonzo et al. 2005), the pollinators of avocados have never been described in California. We know that crop visitation by pollinators increases with surrounding natural habitat, which improves crop yield (Eeraerts et al 2021), but it is unknown if natural habitat improves abundance and diversity of wild pollinators. Furthermore, there is no consensus on the optimal distance from orchards or the size of natural vegetation patches required to achieve these benefits. This gap in knowledge leaves avocado growers without relevant guidelines for using non-crop vegetation to support pollinators, even though many show interest in enhancing natural habitats for improved ecosystem services (Esquivel et al 2021). Avocados are likely dependent upon a unique community of pollinator species, so it is important to address how these pollinators respond to natural vegetation at different spatial scales (Sagwe et al 2022). The objective of this project is to **provide clear, applicable recommendations to help growers establish natural vegetation on orchard margins and enhance wild pollinators, ultimately supporting avocado yields.** We will share the results of our work through at least one field day, a minimum of two blog posts through the UC ANR Topics in Subtropics blog, and communication with the California Avocado Society.

Study Design

This study will be conducted in eight avocado orchards and four riparian sites throughout Ventura County. At each orchard site we will establish a transect that is 150 meters long, running from the edge of an orchard block to the center of the block. Half of the orchard research sites will have bare margins and half will have vegetated margins (either planted hedgerows or naturally-occurring native vegetation) . Additionally, the sites vary in distance to natural riparian habitat on the landscape scale. We will use sites in the riparian channel to catalog pollinator species that could be found in orchards, therefore using them as a control for pollinator diversity. At each site, we will survey wild pollinators using pan traps and blue vane traps. These traps will be set in openings next to trees at the 0m, 75m, and 150m points along the transect. Arthropods will then be transferred to the lab for identification to the lowest taxonomic unit possible. We will characterize variation in pollinator abundance, diversity, and community structure among riparian transects, orchards adjacent to the riparian corridor, and orchards distant from the riparian corridor. We will also assess whether pollinator abundance and diversity are higher in orchards with hedgerows on their margins.

Project Timeline: 2025



Support from CAC

Support from CAC is critical for the success of this project and supports the training of PI Carson Louderment, a graduate student interested in pursuing entomology and agricultural research. Furthermore, this project will support the training of one undergraduate assistant in field methods in Ventura County, which faces a lack of trained agricultural sciences personnel.

Budget	**Description**	**Year 1**
Travel to the field and outreach events from Pomona	Gas & mileage: 67 cents/mile ~ 180 miles round trip ~40 miles between sites ~ 7 trips	$1,032
Accommodations	Hotel 2 nights/trip ~7 trips/year ~$200/night	$2,800
Food per diem	$25/day One assistant ~3 days per trip ~7 trips/year	$1,050
Collection equipment	nets, pans, vials, coolers, vane traps	$300
Identification costs	Insect pins, Cornell drawers, shipping samples to experts	$500
Undergraduate Insect Identification Assistant	$17/hour ~100 hours	$1,700
Undergraduate field assistant	$16.50/hour ~21 field days ~120 hours	$1,980
		Total: $9,362

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Title: A pesticide resistance monitoring program for avocado thrips

Principal Investigator: Hamutahl Cohen, Assistant Entomology Advisor, Ventura, UC ANR
Co-Principal Investigator: Bodil Cass, Assistant Subtropical Entomology Specialist, UC Riverside
Co-Principal Investigator: Laura Leger, Postdoctoral Researcher, UC Riverside
Collaborator: Ben Faber, Subtropical Crops Advisor, Ventura, UC ANR

Overview & Importance

Our aim is to develop a regional resistance monitoring program for avocado thrips (*Scirtothrips persea*), an important pest of avocado in Ventura County that is vulnerable to pesticide resistance due to its high fecundity, short life cycle, asexual reproduction, and cryptic behavior. There are over 150 worldwide cases of insecticide resistance associated with different thrips species, including products in 7 chemical classes[1]. Abamectin is the primary chemical control product for avocado thrips because it has strong efficacy and a limited impact on natural enemies – however, resistance with abamectin is likely because it has long a persistence inside leaf tissues which may subject sequential generations of thrips to the same chemical mode of action. Resistance is also likely because some growers apply it more than once a year for control of both avocado thrips in the spring and persea mites later in the season. For avocado thrips, resistance monitoring has not been conducted in over 12 years. To obtain new baseline resistance data for avocado thrips, we will establish study sites in Ventura County and annually monitor avocados thrips for resistance at these sites using bioassays. This program will set the groundwork for offering growers resistance diagnostic services in the future wherein we could compare grower-submitted samples to baseline resistance levels at the nearest study site from this project. This program is important because it is unlikely that abamectin will be easily replaced if lost to resistance.

Objective & Timeline

Objective 1. Pilot field and lab protocols (March 2025 – March 2026)

One of the primary challenges for implementing this project is that thrips are challenging to rear in a lab setting. We will utilize the first year of the project to trial the a) best methods for field collecting thrips, including how to transport thrips and store them prior to lab bioassays, and b) best methods for lab bioassays, including pesticide preparations, rearing receptacles, and timing and conducting mortality assessments. Protocols will be modified from existing literature[2]. Cohen, Cass, and Leger will trial both field and lab protocols in the Spring 2025 during avocado flush and in the Fall 2025 during any secondary flush events. Year one of the project will also be used to identify 4-6 participating study sites for specimen collections and to train a Cooperative Extension Staff Research Associate (SRA) on field and lab protocols for project support.

Objective 2. Describe new baseline resistance levels & develop monitoring network (March 2026 – October 2029)

We will implement resistance monitoring at 4-6 sites and collect thrips twice annually at each site for resistance testing. Our initial goal is to monitor resistance for four growing seasons at the same set of sites to characterize resistance levels and compare them across the region. In brief, the field collection involves sealing young leaves with thrips into plastic bags, then storing in the fridge for a maximum of 24 hours before the lab bioassay. To conduct the lab bioassay, we will collect young avocado leaves with no prior pesticide exposure, treat them with different pesticide concentrations using a hand-held stainless steel sprayer, and place them inside plastic modified Munger cells with 10-15 thrips each. We will assess thrips mortality after 48 hr. under the microscope.

Objective 3. Outreach and extension to growers (March 2026 - March 2029).

Starting in the second year of the project, we will disseminate research progress and results to growers 1) annually through an oral presentation in collaboration with the California Avocado Commission and 2) through an online, interactive web-based resource of resistance data. Extension materials will include education on management practices that can prevent pesticide resistance (e.g. preventing product degradation, adjusting the pH of spray solutions, etc.). Additionally, we will publish through a peer-reviewed journal in the final year of the study.

Support from CAC
Support from CAC is critical for the success of this project, which is currently unfunded. The research team includes early-career UCCE researchers proposing to advance integrated pest management of a key pest of avocado. Our budget includes requests for materials, labor, and travel

UC ANR (Cohen & Faber)	2025	2026	2027	2028	2029
Hand-held pesticide sprayer (B&G)	$450				
4-way nozzle tip (2)	$70				
Munger Cells for bioassay	$200				
Misc. field & lab supplies (e.g. nitrile gloves, distilled water, pesticide product, beakers, fine sable brush, forceps, aspirator, paraffin)	$700				
Staff Research Associate (SRA, 10hr in Year 1, 50hr Year 2-5 at $51/hr for salary + fringe)	$510	$2,550	$2,550	$2,550	$$2,550
Extension materials (website support, printing, food for grower events)		$500	$500	$500	$500
Total	$1,930	$3,050	$3,050	$3,050	$3,050
				TOTAL	**$14,130**

UC Riverside (Cass & Leger)	2025	2026	2027	2028	2029
Travel from UC Riverside to Ventura	$2,000				
Postdoctoral Salary + Fringe (1 month/annually)	$6,801	$7,039			
Publication costs			$2,000		
Total	$8,801	7,039$	$2,000		
				TOTAL	**$17,840**

1. Gao, Y., Lei, Z., & Reitz, S. R. (2012). Western flower thrips resistance to insecticides: detection, mechanisms and management strategies. *Pest Management Science*, *68*(8), 1111-1121.
2. Morse, J., Urena, A., Humeres, E., Robinson, L., Flores, P., & Watkins, P. (2006). Biology, management, and resistance monitoring of avocado thrips and persea mite. In *Proceedings, California Avocado Research Symposium* (pp. 16-24). Santa Ana, CA: California Avocado Commission.

"Investigate and evaluate current research into soil health"

Proposed researcher**:** Dr Andrew J. Krajewski, International Citrus Technologies Pty Ltd, Albany, WA 6330, Western Australia. For California Avocado Commission.

Introduction; scope of review: Main issues for consideration/discussion are: Exactly what is "soil health"? Exactly what is "soil organic matter" (SOM)? How does SOM affect soil health? How does soil health affect plant health and what are potential benefits to growers? Finally, this review will also specifically address the following issues:

1. USDA research on soil organic matter: Evaluation of activities based on the following points: Main factors considered; their basic mechanisms; issues identified and questions asked; the approach followed; critique of experimental methodology followed; soundness of conclusions based on the data collected; possible alternative explanations for findings; other factors not considered and need for more research; confirmation of findings by other comparable reports elsewhere; and the practical applicability of results to Californian avocados.

2. Best way to educate growers to put information into action: Ideally, multiple channels may be used to present growers with practical management options in time for their implementation and at the correct time in the crop phenological cycle.

i. ***On-site***. Grower education and information dissemination through PowerPoint presentations; seminars; practical workshops combining education with in-field viewing of practices; and observation of results of demonstrations trials. These trials should be logical, simple and deductive, showing contrasts between a few treatments. A series of "One trial; one question asked" trials allow powerful deductions to be made. It is important to monitor and record results, and keep records of practices, costs, results, and of agrometeorological data affecting biological processes and resilience of avocado production systems.

ii. **Off-site**. Generating information and its dissemination through one or more of the following channels: **Written** information in support of management decisions. Do what? Where? How? When? What follow-up? **Visual**, through VLOGs, YouTube and other visual channels; **Audio** through podcasts, radio interviews, and social media.

3. Fine-tuning of soil health improvement practices at farm level: Technical transfer activities are based on observable results from research trials, and/or on-farm demonstrations trials and practical experiences. Assisted by data bases of production, records of local agrometeorological data. Maintaining these adds to increasing precision, year by year.

4. Maximising use of on-farm SOM sources: Cornerstone of sustainability is reduced reliance on off-farm inputs. Five potential carbon sources are: **i.** tree pruning debris for wood-chip mulch; **ii**. orchard inter-rows to produce cover crops for mowing and redistribution under trees as mulch; **iii.** material from pruned windbreaks for wood-chip mulch; **iv**. woodlots for harvest of organic material for mulching; **v**. production of compost and compost-based extracts for use to promote soil and plant health.

To compile review: Estimated hours = **180**; over the period January 1-October 31, 2025. Hourly rate: US$125.00 per hour; total cost for review= **US$22,500.00.**

"Provide complete nutrition, beneficial microorganisms and soil conditioners to withstand biotic and abiotic stressors increasing at the same time overall soil and tree health for a higher fruit yield and quality performance"

Tomas Aguayo, Great Crops, 1 Grand Ave, San Luis Obispo, CA 93407

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Great Crops program approach has been proven to provide immediate results during the same growing season for the last 8 years in all avocado growing areas in California influencing positively measurements such as soil microbiome and nutrition, soil available water, temperature and salinity, etc. These results have been achieved by providing the trees with carefully developed materials targeting key physiological stages of tree development: root flushes, flowering, fruit set & enlargement, vegetative growth, etc. This helps decrease biotic and abiotic stressors and at the same time increasing overall tree health and performance.

Besides providing all range of macro and micronutrients on proper ratios for each targeted physiological stage, all these materials supply soil conditioners such as humic and fulvic acids, seaweed, and beneficial fungi and bacteria (such as soil borne diseases control, N fixers, K solubilizers to mention some), all occurring at low pH and positive values of ORP (antioxidant effect).

Results have shown consistently an improvement in tree health and anti-stress promotion, by increasing flowering, fruit set, fruit size, tree canopy, and overall nutrient cycling and uptake; on the other hand, it has been observed, and measured, significant reduction to sometimes non detectable levels of soil borne disease pressure such as *Phytophthora* and *Pythium*, decrease in soil salinity, fruit size and amount, and fruit and flower abortion to mention some.

These breakthrough improvements are attributed to the well-balanced chemistry and composition of these materials that target tree's key stages; soil conditioners to improve water retention and nutrient availability showing clearly lower impact in soil moisture and temperature variability, which promotes a more stable soil microbiome functionality in plant defense mechanisms and nutrient cycling.

Lower leaf surface temperatures have also been recorded under the Great Crops treatment compared to Grower Standard Practices (GSP), indicating a higher photosynthetic activity under abiotic stressors (temperature, salinity, wind, etc.), explaining this way the better performance and recovery of treated trees.

Finally, all these improvements in tree health/performance and recovery under stressful biotic and abiotic conditions have been demonstrated by improvement of the C cycle; this is through better utilization of the atmospheric CO_2 (canopy), and by increasing CO_2 soil sequestration. These measurements have been showing more clear trends in water schedules than Evapotranspiration and/or caliper measurements used for irrigation management due to build up of Soil Organic Carbon and apparent higher efficiency in plant photosynthetic rates.