



## AGENDA

### California Ripe Olive Research Subcommittee Meeting ZOOM/Conference Call November 5, 2020 10:30 AM

**Join Zoom Meeting:**

<https://us02web.zoom.us/j/83588135849?pwd=ajVMWGtVK0o4czFkWStCdnE1T1Vydz09>

**Meeting ID:** 835 8813 5849

**Dial-in:**

**+1669-900-6833**

**Meeting ID: 835 8813 5849 #**

- I. Call to Order**
  - a. Roll Call p.2
  - b. Research Subcommittee Chairman's comments
  - c. Approval of 7-21-20 Research Subcommittee Minutes (**action item**) p.3
  
- II. Discussion and Review of 2020 Projects p.6**
  - a. Budget Status Update p.7
  
- III. Presentation of 2021 Proposals p.26**
  
- IV. Approval of 2021 Budget (**action item**) p.81**
  - a. Closed Session
  
- V. Approval of Authority to the Executive Director and Chairman to approve No-Cost Extensions (**action item**) p.82**
  
- VI. Approval of Authority to the Executive Director and Chairman for Inter-Item Transfers of the Research Subcommittee Budget (**action item**) p.85**
  
- VII. Other Business**
  
- VIII. Adjournment**



## 2020 Research Subcommittee

### Producer Members:

Carolina Bureson
Michael Silveira
Chris Henderson
Pablo Nerey
Ed Curiel
Vito DeLeonardis
Giulio Zavolta
Pat Ricchiuti
Galen Pfeiffer
Mark Heuer

### Handler Members:

Dennis Bureson-Chairman
Matt Miller
John Pieretti
Janet Edwards
Julia Tinsley
Jacob Peters
Sergio Mendez



**California Olive Committee**  
**Research Subcommittee Meeting Minutes**  
**Tuesday, July 21<sup>st</sup>, 2020**  
**9:00 AM**  
**ZOOM/Conference Call**

**I. CALL TO ORDER**

A meeting of the Research Subcommittee was called to order by Dennis Burreson at 9:00 A.M., and the following members were present:

**Members**

Carolina Burreson  
Michael Silveira  
Chris Henderson  
Giulio Zavolta  
Pat Ricchiuti  
Galen Pfeiffer  
Mark Heuer  
Dennis Burreson  
Matt Miller  
Julia Tinsley  
John Pieretti  
Jacob Peters  
Janet Edwards

**Affiliation:**

PRODUCER  
PRODUCER  
PRODUCER  
PRODUCER  
PRODUCER  
PRODUCER  
PRODUCER  
HANDLER  
HANDLER  
HANDLER  
HANDLER  
HANDLER  
HANDLER

**Others Present:**

Todd Sanders	COC
Elizabeth Carranza	COC
Elise Oliver	COC
Kathie Notoro	USDA
Felix Musco	MUSCO

With the appropriate number of members from producers and handlers in, a quorum was established.

**MOVED by Galen PFEIFFER, duly seconded by John PIERETTI, and carried THAT the minutes of the 11.14.19 Research Subcommittee meeting be approved. (Motion 7.21.20 #1)**

**II. Review of 2019 Research Final Reports**

Elise OLIVER provided a brief summary of three No Cost Extension Final Reports for the 2019 year. Included in the packet was a chart highlighting in red the three researchers who were granted No Cost Extensions. Final Reports for these researchers were emailed out after the meeting.

**III. Update on CA Specialty Crop Block Grant Program Applications**



Elise OLIVER discussed the status of the current grant application for the project entitled, Preventing Xylella Fastidiosa in California Ripe Olives by Determining Susceptibility of California Ripe Olive Varieties. The application is currently in phase two of the process and the COC is expecting to hear back in fall 2020 on whether or not we will be receiving the grant. Elise also asked subcommittee members to start thinking about future grant ideas that they would like the COC to apply for. She will be reaching out to subcommittee members in the near future to further discuss grant ideas so the COC team can begin the application process for the 2020 year.

#### **IV. Discussion and Approval of 2021 Research Priorities**

Each year the Research Subcommittee sets priorities of research they would like executed on their behalf for the following year. These efforts are to fund more specific and calculated research to enhance the benefits to the industry. Once the priorities are set they are provided to the University of California and other Land-Grant Institution liaisons to request proposals from researchers. Proposals will be reviewed for funding in November by the subcommittee.

#### **List of Priorities:**

- Mechanical Harvesting for high density orchards and existing orchards
- Mechanical harvesting transition
- Cost study to determine which trees are convertible for trunk shaking
- Loosening Agents
- Management of black scale
- Management of olive knot
- Canopy Management
- Olive Fruit Fly Trapping
- Evaluation of drone technology and satellite imagery to measure canopy density and yields
- DNA Study

**MOVED by Pat RICCHIUTI, duly seconded by Julia TINSLEY, and unanimously carried THAT the list of new priorities be approved for 2021 priorities. (Motion 7.21.20 #2)**

#### **V. Other Business**

#### **VI. Adjournment**

- a. Chairman Dennis BURRESON adjourned the meeting at 9:57 a.m.

*Elise Oliver*

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Date: July 28, 2020

Elise Oliver, California Olive Committee



**Summary of Motions for July 21, 2020**

**Motion 7.21.20 #1**

**APPROVED**

**MOVED by Galen PFEIFFER, duly seconded by John PIERETTI , and carried THAT the minutes of the 11.14.19 Research Subcommittee meeting be approved.**

**Motion 7.21.20 #2**

**APPROVED**

**MOVED by Pat RICCHIUTI, duly seconded by Julia TINSLEY, and unanimously carried THAT the list of new priorities be approved for 2021 priorities.**

**\*\*\*INFORMATION ONLY\*\*\***

**FROM:** COC RESEARCH SUBCOMMITTEE

**SUBJECT:** PROGRESS REPORTS FOR 2020

**BACKGROUND:** Each year, the Subcommittee funds research projects and requests progress reports from researchers. Provided in your packet are the current research progress reports for six projects.

### 2020 Research Projects-Updated 10/25/2020

Researcher	Project	Amount	Finalized MOU	Paid thus far	% Paid	No Cost Extension
Reza Ehsani Louise Ferguson	Combining trunk shaking and canopy shaking for a highly efficient, low cost olive harvester.	\$92,699	2/1/2019	\$ 55,619.40	60%	
Debra Keenan	Evaluation of new chemistries to control Olive Fruit Fly	\$25,000	2/2/2019	\$ 15,000.00	60%	
Carol Lovatt Elizabeth Fichtner	Managing Alternate Bearing in Olive with PGRs and Pruning	\$23,232	2/14/2020	\$ 13,939.20	60%	6/30/2021
Frank Zalom Joanna Fisher	Control of overwintering olive fruit fly using insect pathogenic fungi	\$17,196	2/14/2020	\$ 10,317.60	60%	6/30/2021
J. E. Adaskaveg	Epidemiology and management of olive knot caused by <i>Pseudomonas savastanoi pv. savastanoi</i>	\$16,650	2/5/2019	\$ 9,990.00	60%	
J. E. Adaskaveg	Management of foliar diseases of olive (peacock spot)	\$10,000	2/6/2019	\$ 6,000.00	60%	
Jim Stewart	Southern San Joaquin Valley Olive Fruit Fly Monitoring Project	\$6,400	2/7/2019	\$ 3,840.00	60%	
Ernie Simpson	Sacramento Valley Olive Fruit Monitoring Project	\$6,500	2/8/2019	\$ 3,900.00	60%	
	<b>Total</b>	<b>\$ 197,677.00</b>		<b>\$118,606.20</b>		

**CALIFORNIA OLIVE COMMITTEE**  
**PROJECT PLAN PROGRESS REPORT**

Workgroup/Department: School of Engineering – Mechanical Engineering

Project Year:                      Anticipated Period of Performance: 03/01/2020 – 02/28/2021

**Project Title:** **Combining trunk shaking and canopy shaking for a highly efficient, low-cost olive harvester**

**Project Leaders:** Reza Ehsani (Professor, University of California, Merced, 5200 N. Lake Road, Merced, CA 95343, (209) 228-3613, [rehsani@ucmerced.edu](mailto:rehsani@ucmerced.edu))

**Cooperators:** Louise Ferguson, CE Pomologist, Department of Plant Sciences, UC Davis, Email: [lferguson@ucdavis.edu](mailto:lferguson@ucdavis.edu), Phone: (559) 737-3061

**Problems and Significance:**

Harvesting is a major cost of production for many crops, including olive. Although some olive growers are using trunk shakers with some success, this method has not been widely utilized because the willowy characteristics of olive trees prevent the effective transmission of vibrational energy from the trunk to the small branches where the fruits are located. To remove the fruit from trees, due to the willowy characteristics of olive trees, a trunk shaker requires a large amount of shaking energy, which can damage the tree roots. Also, for some older orchards, the trunk shaker may not be an option due to the size and shape of the canopy.

Ehsani's group at UC Merced used an alternative design approach and developed a lighter weight canopy contact shaker-based fruit removal system that can accommodate larger trees. This system has shown some promising results as well. The UC Merced design was able to produce the maximum shaking energy at the fruit level as opposed to the trunk, and hence, less damage to the tree. However, it took a longer time to shake each tree.

Based on some initial field testing conducted in the fall of 2019, it seems that a combination of trunk shaking and canopy shaking can provide the best fruit removal for olives. In this project, we propose to evaluate the effect of a combination of trunk and canopy shaking on olive fruit removal. We intend to conduct extensive field tests to assess the best design parameters, such as amplitude and frequencies. These parameters are needed for designing and building a system that combines both canopy and trunk shaking together.

**Objectives:**

The ultimate goal of this study was to develop a highly efficient, low-cost fruit harvesting machine for olives. The specific objectives are as follows:

- Study whether a combination of canopy shaker and trunk shaker is a superior method to other alternatives in maximizing fruit removal and minimizing harvest time.

- Find the best shaking parameters (frequency, amplitude, duration) for a combination of trunk shaker and canopy shaker.
- Evaluate the effects of fruit removal using both shaking systems on fruit and tree damage.
- Based on the results from field tests, design a new harvesting system for an olive that uses widely available trunk shaking equipment modified with a relatively low-cost canopy-contact harvester and catch-frame system.

**Experimental Procedures:**

An extensive field experiment was done on September 30<sup>th</sup>, 2020 in Nickels olive orchard (Woodland, CA). A trunk shaker built by Orchard Machinery Corporation (OMC) was used alongside the UC Merced canopy shaker. For each shaker machine (trunk and canopy shaker) three different shaking frequency was chosen. Eleven trials were conducted, including the nine combinations of shaking frequencies (Figure 1), one trial on using solely trunk shaker and one trial using UC Merced canopy shaker only (Table 1). Each trial was replicated three times (a total of 33 trees). Canopy shaker has been set to 2" off-center distance, generating oscillation with 4" amplitude. Rotational speed was set to 100, 150, and 200 rpm for the experiment. The trunk shaker intensity was set to low, medium, and high. The shake duration was set to 15 seconds.

*Table 1. Experiment design for selecting the optimum combined shaking frequency. Each treatment will be replicated three times.*

Trunk shaker intensity  Canopy shaker (rpm)	Low	Medium	High
100	Trial-1	Trial-2	Trial-3
150	Trial-4	Trial-5	Trial-6
200	Trial-7	Trial-8	Trial-9
Canopy shaker		Trial-10	
Trunk shaker		Trial-11	

There were three wireless accelerometer sensors installed on each tree canopy. Two sensors were attached on the side of canopy shaker and one was installed on the opposite side.

Before each shake 4 to 6 tarps were laid on ground to collect harvested olives. After shake, mechanically harvested olives were weighted and a sample was labeled and prepared to be sent to a laboratory for quality rating. A gleaning crew were hired to remove remaining olives on tree. The manually harvested fruit was weighted and recorded. Harvest efficiency is calculated using equation below.

$$Efficiency = \frac{Mechanically\ harvested\ (lb)}{Manually\ harvested\ (lb)} \times 100$$



Figure 1 Trunk shaker and canopy shaker, shaking an olive tree simultaneously

### **Preliminary Results:**

Harvest efficiency for each of 11 trials has shown in Figure 2. Trial 1 through trial 9 has used both UC Merced canopy shaker and the OMC trunk shaker. Trial 10 has used only the UCM canopy shaker and trial 11 has used the OMC trunk shaker solely.

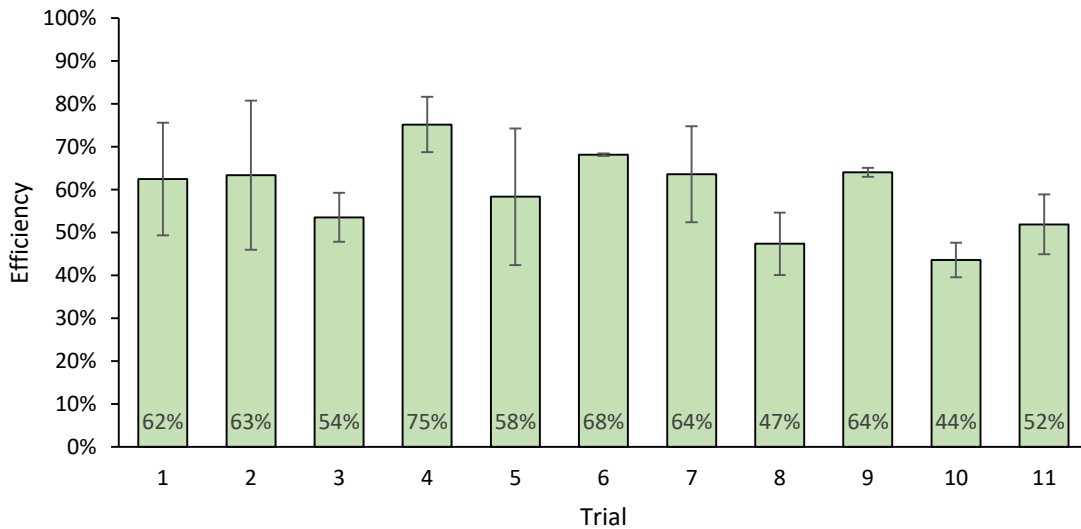


Figure 2 Harvest efficiency for all trials. Trials 1 to 9 were used both canopy shaker and trunk shaker simultaneously, Trial 10 has used UC Merced canopy shaker only and trial 11 has used the OMC trunk shaker.

This figure shows almost all the trials using both shakers at the same time, except trial eight had a better harvest efficiency compared to using each type of shaker individually. Figure 3 shows the average harvest efficiency of all three shaking methods. This figure shows the combined shaker method has improved harvest efficiency by 41% compared to canopy shaker alone and 19% compared to trunk shaker.

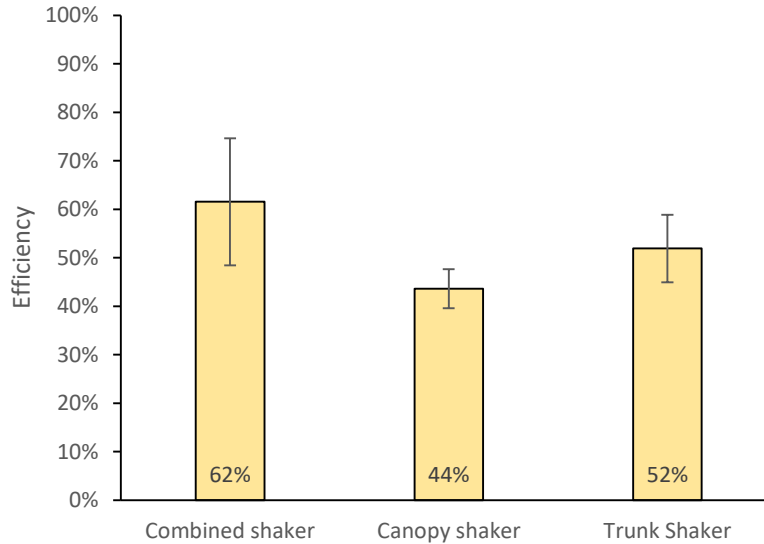


Figure 3 Comparing harvest efficiency of all three methods.

These results strongly show shaking an olive tree simultaneously using a trunk shaker and a canopy shaker will result in higher harvest efficiency. Among the nine trials which used both shakers, trial 4 and 6 showed the best harvest efficiency of 75% and 68% respectively. Vibration data and lab-quality results will be presented in the final report. Also, a modified canopy shaker design was discussed and conceptualized based on field observation and will be proposed at a later stage.

# Research 2000

Trial ID: oliveff2020 1_2	Location: Corning	<b>olive fruit fly control</b>
Protocol ID: oliveff2020 1	Investigator: Debra Keenan	Trial Year: 2020
Project ID:	Study Director:	
	Sponsor Contact:	

**General Trial Information**  
**Investigator:** Debra Keenan

**Trial Status:** E established

**ARM Trial Created On:** Oct-5-2020

**Conducted Under GLP:** No  
**Conducted Under GEP:** No

**Objectives:**  
 Determine the best control measures for Olive Fruit Fly. Search new insecticides for potential control. Determine if the materials cause injury to the crop. Also determine if the insecticides have any control of olive scale which is becoming a bigger pest in the area.

**Investigator:** Debra Keenan

**Crop Description**  
**Crop 1:** C OLVEU Olea europaea Olive **BBCH Scale:** BPER

**Pest Description**  
**Pest 1 Type:** I  
**Common Name:** Bactrocera oleae  
**Attributes:** Olive fruit fly

**Site and Design**  
**Treated Plot Width:** 18 FT  
**Treated Plot Length:** 20 FT  
**Treated Plot Area:** 360 FT<sup>2</sup> **Treatments:** 8  
**Replications:** 4 **Study Design:** RACOB L Randomized Complete Block (RCB)

**Application Description**

	A	B	C
<b>Application Date</b>	May-30-2020	Jun-24-2020	
<b>Appl. Start Time</b>	7:30 AM	7:00 AM	
<b>Appl. Stop Time</b>	9:00 AM	8:30 AM	
<b>Application Method</b>	GF	gf	
<b>Application Placement</b>	canopy	canopy	
<b>Applied By</b>	D Keenan	D Keenan	
<b>Appl. Entry Date</b>	Oct-5-2020	Oct-5-2020	
<b>Air Temperature Start, Stop</b>	71 F	72 F	
<b>% Relative Humidity Start, Stop</b>	20	30	
<b>Wind Velocity+Dir. Start</b>	0	0	
<b>Wet Leaves (Y/N)</b>	N no		

**Crop Stage At Each Application**

	A	B	C
<b>Crop 1 Code, BBCH Scale</b>	OLVEU BPER	OLVEU BPER	OLVEU BPER

**Pest Stage At Each Application**

	A	B	C
<b>Pest 1 Code, Type, Scale</b>	I	I	I

**Application Equipment**

	A	B	C
<b>Appl. Equipment</b>	gf	gf	
<b>Equipment Type</b>	GF	GF	

Context	Date	By	Notes
STATUS	Oct-5-2020	Debra Keenan	Automatically added by ARM: Trial Status updated to 'S' during trial creation.
STATUS	Oct-5-2020	Debra Keenan	Automatically added by ARM: Trial Status updated to 'E' when Application Date entered.



yield result in an OFF crop that is followed in one to two years, depending on the length of time the trees need to recover, in an ON crop. Conversely, optimal climate conditions during flowering and fruit set, such that natural fruit thinning fails to occur result in an ON crop that is followed by an OFF crop. Climate events repeat in a random manner. Thus, there is a reoccurring need for a management strategy to mitigate the negative economic impact of AB on table olive growers and the industry.

To mitigate alternate bearing in ‘Manzanillo’ olive trees, it is necessary to increase the number of non-bearing shoots during the ON-crop year by removing inflorescences or fruit. The ON crop of fruit inhibits summer vegetative shoot growth, reducing the number of nodes that can bear floral buds the following spring (first reported by Sibbett, 2000). Our research confirmed the findings of Sibbett (2000) and was the first to document that the ON crop also causes bud abscission of existing putative floral buds through harvest, inhibits the transcription of genes necessary for flower development, and reduces bud break in spring following the ON-crop (Fichtner and Lovatt, 2018; Fichtner et al., 2017). For ON-crop trees, our research results documented that the severity of these effects is greater for bearing shoots, the majority of shoots on ON-crop trees, than non-bearing shoots. Further, our research results demonstrated that plant growth regulator (PGR) treatments using a cytokinin and/or an auxin transport inhibitor significantly increased return bloom on non-bearing shoots, but were not sufficiently effective on bearing shoots (Fichtner and Lovatt, 2018; Fichtner et al., 2017; Chao, 2014). Only non-bearing shoots on ON-crop trees, which are in the minority, contribute a significant number of inflorescences to spring bloom following the ON-crop year. Taken together, these results provide strong evidence that increasing the number of non-bearing shoots on ON-crop olive trees is required to increase return bloom and yield the following year.

This is due to the fact that only non-bearing shoots, which are in low number on ON-crop trees, produce a significant number of inflorescences the following spring and thus, produce the majority of the return crop (Fichtner and Lovatt, 2018; Fichtner et al., 2017; Chao, 2014). Return bloom is dramatically reduced on bearing shoots, the majority of shoots on ON-crop trees, due to the combined effects of the total fruit on the tree (whole tree effect of crop load) and individual fruit set on bearing shoots (localized effect of fruit) of ‘Manzanillo’ olive trees which (i) inhibit summer vegetative shoot growth and thereby reduce the number of nodes that can produce floral (inflorescence) buds the following spring (Sibbett, 2000), (ii) increase floral bud abscission, (iii) inhibit flower formation by preventing floral gene transcription, and (iv) reduce bud break in the spring following the ON-crop year (Fichtner and Lovatt, 2018; Fichtner et al., 2017; Chao, 2014). The overall goal of our research is to develop a management strategy that maximizes total yield and yield of commercially valuable size fruit annually such that the sum of two annual yields is greater than the sum of the ON/OFF yields of an alternate bearing cycle.

**Objectives for 2020 (Year 1).** Our research during the prior 3 years compared the efficacy of a PGR chemical flower thinning treatment (naphthaleneacetic acid [NAA], ALCO<sup>®</sup> Olive Stop<sup>™</sup>; AMVAC Corp., already registered for use on olive) at full bloom and mechanical pruning (hedging) after fruit set (28 days after full bloom) with untreated ON- and OFF-crop control trees. Trees in all treatments were topped to approximately 14 feet each year. The trees were skirted on July 1, 2020. The objective for 2020 was to determine the efficacy of applying each crop thinning treatment to one side of the tree one year and then the other side of the tree annually versus every other year to mitigate alternate bearing and then to select the best strategy and combine it with PGR treatments to increase annual yield and 2-year cumulative total yield and yield of commercially valuable size fruit to greater than the sum of a 2-year ON/OFF cycle in an alternate bearing orchard.

**Research Accomplishments for 2020.**

### 1) Treatment effects on return bloom in 2020.

A visual estimate of bloom was made for the east and west sides of each tree before treatments were applied to determine the effect of the previous year's treatments on return bloom. The results for the east and west sides of each tree were averaged to give a value per tree. Bloom estimates for 2020 provided important information on the effects of the 2019 treatments on return bloom in 2020 (Table 1). This year's bloom estimates confirmed that treating trees with NAA or pruning on one side of the tree and then other on an annual basis removed bloom too frequently and resulted in significantly lower average return bloom for individual trees than applying these treatments to alternate sides of the tree every other year. The data in Table 1 displays the comparison of the average estimated 2020 return bloom for trees in treatments 2 and 3, which had the first side of the tree treated in 2018, an ON-crop year and were allowed to recover for 1 year before the second side of the tree was treated in 2020 and for trees in treatments 5 and 6, which were treated on one side of the tree one year and then the other side of the tree the following year for 4 consecutive years. Return bloom is greater for trees treated every other year than annually for NAA-treated and pruned trees, respectively.

### 2) Treatment effects on yield in 2020.

We also made visual estimates of yield on the east and west side of the trees with a calculated average per tree just prior to harvest (Data not shown). There was a strong correlation between the average estimated bloom per tree and the average estimated yield per tree ( $r = 0.86$ ,  $P < 0.0001$ ). Both average estimated bloom per tree and average estimated yield per tree were strongly correlated with total yield as kg per tree at harvest ( $r = 0.80$ ,  $P < 0.0001$  and  $r = 0.88$ ,  $P < 0.0001$ , respectively). Yield per tree was as expected based on the bloom estimates, with exception of the application of NAA to one side of the tree and then the other every other year (Treatment 2) (Table 1). We expected the yield to be greater. The product might have over thinned in response to three days of day-time temperatures  $\geq 95$  °F that occurred three days after application. This possibility is behind the registration of a new NAA product by AMVAC (Mandolin<sup>®</sup>) that is less sensitive to high temperatures and thus, less prone to over-thinning. Mandolin<sup>®</sup> will replace Olive Stop<sup>®</sup>. Our goal is to test this new product over the next two years. Alternatively, this result might indicate that thinning treatments should not be imposed if the bloom average on the untreated side of the tree in the current year is less than 2 on a scale from 0 to 3. This evaluation is not onerous, requiring only a quick walk or drive through a block.

### 3) Treatment effects on fruit size and quality.

Samples were collected for the determination of treatment effects on fruit size and quality, but sample analyses were not completed and statistically analyzed in time for this report.

### A summary of what we have learned over the past four years.

#### 4) Treatment effects on return bloom 2017-2020.

Examination of the bloom estimates prior to treatment (Table 2) and resulting yields (Table 3) for the four years of the research confirms that thinning treatments (NAA or pruning) should not be applied if estimated bloom on the side of the tree that will be left untreated in the current year is less than 2.0, as the resulting total yields are too low. Thus, flexibility in the application of a fruit thinning strategy will be required rather than strict adherence to a prescribed pattern of treatment. This is especially true when a climate event initiates a new alternate bearing pattern as in 2019, when all trees were "ON" independent of the previous year's crop load. Treatments should have been applied in 2019 and not in 2020. Yield results from using

NAA versus pruning have not been significantly different, except for the application NAA in Treatment 2 in 2020 (Table 3). Thus, growers could interchange the use of NAA and pruning to maintain the size of their trees as desired.

#### **5) Treatment effects on yield 2017-2020.**

In all cases, treatments were first applied to ON-crop trees. All trees in the experiment have now produced two ON crops and two OFF crops. (Table 3). All treatments have reduced the severity of alternate bearing based on the calculated Alternate Bearing Index (ABI) for each 2-year ON-/OFF-yield cycle.  $ABI = (\text{year 1 yield} - \text{year 2 yield}) / (\text{year 1 yield} + \text{year 2 yield})$ , in which yield is total kilograms of fruit per tree and the difference in yield between years 1 and 2 is expressed as an absolute value. An ABI of zero means no alternate bearing, whereas an ABI of one is complete alternate bearing, i.e., crop one year, no crop the other year (Pearce and Dobersek-Urbanc, 1967). From 2017 to 2020, ABI has decreased in treated trees from an average of 0.75 to 0.55. The average for the untreated ON-/OFF-crop control trees for this period decreased to 0.68. However, the ABI for trees treated annually versus every other year is significantly lower for trees treated every other year for 2018-2019 and 2019-2020 ( $P < 0.0001$ ), which indicates less variation in annual yield when trees are treated on one side and then the other side every other year.

#### **6) Treatment effects on fruit size and quality 2017-2020.**

We have previously reported significant benefits on fruit size and yield of green-colored fruit (prevention of fruit blackening) in response to fruit thinning treatments to even out yield in an alternate bearing orchard. An additional benefit of our research was the documentation of the strong inverse relationship between the proportion of black and partially black fruit per tree at harvest and total yield per tree ( $r = -0.60$ ;  $P < 0.0001$ ) first observed by Dr. Fichtner, with OFF-crop control trees having the largest proportion of black and partially black fruit and the fewest green fruit (only 54%) ( $P < 0.0003$ ). Conversely, the proportion of fruit that remained green through harvest increased in parallel with total yield per tree ( $r = 0.60$ ;  $P < 0.0001$ ) with the majority (90%) of the fruit remaining green on ON-crop control trees and NAA and pruned trees having 81% and 75% green fruit, respectively ( $P < 0.0003$ ). Thus, a greater proportion of green fruit might be another benefit derived from fruit thinning strategies to increase return yield following the ON-crop year. Having more uniform yields also stabilizes fruit size, reducing the potential for large numbers of petite or extra-large fruit.

#### **Goal for the next two years.**

Taken together, the results of this research identify the strategy of applying NAA or pruning treatments starting in an ON-crop year with reapplication every other year as the better strategy for evening out annual yields in an alternate bearing orchard, improving yield of commercially valuable size fruit, and reducing the yield of black fruit at harvest. The goal for the next two years is to further increase bloom and yield following the ON-crop year using PGR materials (not requiring a new registration) that were shown to increase summer vegetative shoot growth and fruit size during the ON-crop year, and bud break the following spring on nonbearing shoots in our earlier research to maintain good fruit size in higher yield years and to increase return bloom following ON-crop (higher yield) years. We will also test the efficacy of the new AMVAC NAA product, Mandolin<sup>®</sup> to replace Olive Stop<sup>®</sup>, for fruit thinning of olive because it is less prone to over-thinning due to high temperatures. This product should help to further stabilize yields and fruit size. The overall goal of our next research is to optimize the NAA and pruning strategy applied to one side of the tree and then the other side of the tree every other year with flexible application of this strategy in combination with PGR-materials (not requiring new registration) that maximize total yield and

yield of commercially valuable size fruit annually, such that the sum of two annual yields is greater than the sum of the ON/OFF yields of an alternate bearing cycle.

**References:**

Chao, Y.Y. 2014. Alternate Bearing in Olive (*Olea europaea* L.). MS Thesis. University of California, Riverside, CA.

Fichtner, E., Lovatt, C.J. 2018. Alternate bearing in olive. *Acta Hort.* 1199:103-108. doi:10.17660/ActaHortic.2018.1199.17and PGRs

Fichtner, E.J., Y.Y. Chao, L. Ferguson, J.S. Verreynne, L. Tang and C.J. Lovatt. 2017. Repeating cycles of ON and OFF yields in alternate bearing olive, pistachio and citrus trees — *Different mechanisms, common solutions*. *Acta Hort.* (in review)

Pearce, S.C. and S. Dobersek-Urbanc. 1967. The measurements of irregularity in growth and cropping. *J. Hort. Sci.* 42(3):295–305.

Sibbett, S. (2000). Alternate bearing in olive trees. *California Olive Oil News*. 3(12),1

**Table 1.** Effect of crop load and two fruit thinning treatments, foliar application of the PGR NAA at full bloom and pruning 28 days after full bloom (May 31) in 2019 to one side of the tree and then the other annually or every other year on the intensity of the 2020 bloom of ‘Manzanillo’ olive trees (estimated prior to full bloom on May 5, 2020, using the scale in footnote “z”) and total yield as kg/tree.

Completed	2019 <sup>y</sup>	2020	2020 Bloom estimate <sup>z</sup> (Before 2020 treatment)			2020 yield
	Treatments	To be done	West side of tree	East side of tree	Average Per tree	kg/tree
1	OFF-crop control	ON-crop control	2.3 a <sup>x</sup>	2.6 a	2.4 a	79.3 a
2	No treatment in 2019; treated every other year	NAA – West side of tree @ full bloom	1.8 bc	1.8 bc	1.8 bc	28.5 b
3	No treatment in 2019; treated every other year	Pruned - West side of tree @ 28 days after full bloom (June 2)	2.1 ab	2.3 ab	2.2 ab	59.6 a
4	ON-crop control	OFF-crop control	0.6 d	0.8 d	0.7 e	9.7 c
5	NAA - West (OFF crop) side of tree @ full bloom	NAA - East side @ full bloom	1.4 c	1.2 cd	1.3 cd	24.2 b
6	Pruned - West (OFF crop) Side of tree @ 28 days after full bloom (May 31)	Pruned - East side @ 28 days after full bloom (June 2)	0.1 e	1.5 c	0.8 de	20.4 b
<i>P</i> -value			< 0.0001	< 0.0001	< 0.0001	< 0.0001

<sup>z</sup>Bloom was evaluated on the following scale: 0, no inflorescence; 1, low floral intensity; 2, medium floral intensity; and 3, high floral intensity.

<sup>y</sup>All trees were topped in July 7, 2017, May 30, 2018, May 31, 2019 and June 1, 2020. All trees were skirted on July 1, 2020

<sup>x</sup>Mean values within a vertical column followed by different letter s are significantly different at the specified *P* level by Fisher’s Protected LSD test.

**Table 2.** Effects of crop load and two fruit thinning treatments, foliar application of the PGR NAA at full bloom and pruning after full bloom (June 26, 2017, May 30, 2018, May 31, 2019, and June 2, 2020) to one side of the tree and then the other side annually or every other year on 'Manzanillo' olive tree on estimated return bloom the following year in 2018, 2019 and 2020 prior to treatment. Data in bold red indicate bloom to be thinned in a specified year.

2017 <sup>z</sup>	2018	2019	2020	2018	2018	2019	2019	2020	2020
	Treatment <sup>z</sup>			W/E	Avg.	W/E	Avg.	W/E	Avg.
1 OFF-crop control	ON-crop Control	OFF-crop control	ON-crop control	2.7a <sup>y</sup> /2.6a	2.7 a	1.3c/1.8cd	1.6 b	2.3a/2.6a	2.4 a
2 No treatment	NAA-East side of tree	No treatment	NAA-West side of tree	2.2a/ <b>2.3a</b>	2.3 a	1.8b/2.1bcd	1.9 b	<b>1.8bc</b> /1.8bc	1.8 bc
3 No treatment	Pruned-East side of tree	No treatment	Pruned-West side of tree	2.6a/ <b>0.4b</b>	2.6 a	1.9b/1.6d	1.8 b	<b>2.1ab</b> /2.3ab	2.2 ab
4 ON-crop control	OFF-crop control	ON-crop control	OFF-crop control	0.7bc/0.4b	0.6 b	2.6a/2.8a	2.7 a	0.6d/0.8d	0.7 e
5 NAA-West side of tree	NAA-East side of tree	NAA-West side of tree	NAA-East side of tree	1.1b/ <b>0.9b</b>	1.0 b	<b>2.5a</b> /2.4ab	2.4 a	1.4c/ <b>1.2cd</b>	1.3 cd
6 Pruned-West side of tree	Pruned-East side of tree	Pruned-West side of tree	Pruned-East side of tree	0.6c/ <b>0.9b</b>	0.7 b	<b>2.7a</b> /2.2bc	2.4 a	0.1e/ <b>1.5c</b>	0.8 de
<i>P</i> -value				< 0.0001/ < 0.0001	< 0.0001	< 0.0001/ 0.0002	< 0.0001	< 0.0001	<0.0001

<sup>z</sup> All trees were topped on July 7, 2017, May 30, 2018, May 31, 2019 and June 1, 2020.

<sup>y</sup> Mean values within a vertical column followed by different letters are significantly different at the specified *P* level by Fisher's Protected LSD test.

**Table 3.** Effects of crop load and two fruit thinning treatments, foliar application of the PGR NAA at full bloom and pruning after full bloom (June 26, 2017, May 30, 2018, May 31, 2019, and June 2, 2020) to one side of the tree and then the other side annually or every other year on 'Manzanillo' olive tree annual yield in 2017, 2018, 2019 and 2020, 2-year cumulative for 2017+2018, 2018+2019, and 2019+2020.

2017 <sup>z</sup>	2018	2019	2020	2017	2018	2019	2020	Cumulative yield		
Treatment <sup>z</sup>				Yield	Yield	Yield	Yield	2017+2018	2018+2019	2019+2020
				(kg/tree)	(kg/tree)	(kg/tree)	(kg/tree)	(kg/tree)	(kg/tree)	(kg/tree)
1 OFF-crop control	ON-crop Control	OFF-crop control	ON-crop control	25.3 c <sup>y</sup>	121.5 a <sup>x</sup>	134.6 d	79.3 a	146.9 a	256.1 a	213.8 a
2 No treatment	NAA-East side of tree	No treatment	NAA-West side of tree	20.3 c	83.6 b	156.1 bcd	28.5 b	103.8 a	239.7 abc	184.7 b
3 No treatment	Pruned-East side of tree	No treatment	Pruned-West side of tree	15.4 c	100.5 ab	141.6 cd	59.6 a	115.9 a	242.0 abc	201.2 ab
4 ON-crop control	OFF-crop control	ON-crop control	OFF-crop control	103.9 a	26.8 c	211.4 a	9.7 c	130.7 a	238.2 abc	221.1 a
5 NAA-West side of tree	NAA-East side of tree	NAA-West side of tree	NAA-East side of tree	71.3 b	39.6 c	179.8 b	24.2 b	110.9 a	219.3 bc	204.0 ab
6 Pruned-West side of tree	Pruned-East side of tree	Pruned-West side of tree	Pruned-East side of tree	69.3 b	47.5 c	161.4 bc	20.4 b	116.9 a	208.9 c	181.7 b
<i>P</i> -value				< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.1182	0.0724	0.0419

<sup>z</sup> All trees were topped on July 7, 2017, May 30, 2018, May 31, 2019 and June 1, 2020.

<sup>y</sup> Mean values within a vertical column followed by different letters are significantly different at the specified *P* level by Fisher's Protected LSD test.

**Interim Report For 2020  
California Olive Committee  
Submitted October 15<sup>th</sup>, 2020**

**Project Title:** Control of overwintering olive fruit fly using insect pathogenic fungi (Year 2)

**Project leaders:** Frank Zalom and Joanna Fisher Location: UC Davis

**Cooperating Personnel:** Emily Symmes (Area IPM Advisor) UC Cooperative Extension, Cindy Kron (Area IPM Advisor) UC Cooperative Extension

**Requested Funding for 2020:** \$17,196

**Objectives:**

- (1) Evaluate efficacy of using commercially available insect pathogenic fungi to control overwintering olive fruit fly, *B. oleae*, populations.
- (2) Evaluate the capacity of insect pathogenic fungi to persist in olive orchards under California field conditions.
- (3) Determine when olive fruit fly larvae drop out of infested fruit in the fall.

**Background:**

Olive fruit fly, *Bactrocera oleae*, is the most important insect pest of California table olives. Olive fruit fly is primarily managed with a single product, GF-120 spinosad bait, for which resistance is well documented. Continued use of GF-120 bait could lead to more widespread and higher levels of resistance, resulting in the total loss of olive fruit fly control by this insecticide in many CA olive growing regions. The pyrethroid insecticide fenpropathrin (Danitol) has been registered more recently for olive fruit fly control. However, pyrethroids are well known to disrupt scale and mite biological control in other systems where they are used, leading to secondary pest outbreaks. It is imperative that additional control strategies be developed. Particularly useful would be those strategies that target the overwintering generation, which survive as pupae in the soil. This proposal is intended to test the efficacy of using fungal insect pathogens to control overwintering olive fruit fly populations that are already registered commercial products.

We proposed testing the use of insect pathogens to control overwintering OLF larvae and pupae in fall as well as emerging adults in spring through lab and field trials. The fungi would be applied to the soil prior to larval drop in the fall and a second time prior to adult emergence in the spring. In year 1 (fall 2019 – spring 2020), we evaluated Met52, a *Metarhizium brunneum* based product, and two *Beauveria bassiana* based products, BioCeres and Mycotrol, that contain different strains of the fungus. In year 1, it was found that larvae and pupae have low susceptibility to all three products even at high application rates. However, the preliminary results suggest that adults are susceptible to Mycotrol and can likely acquire a lethal infection when emerging from fungal treated soil under lab conditions. Following further lab bioassays this fall to confirm these results, it is likely that only a single spray of an insect pathogenic fungi (IPF) will be applied at the cage and field study sites in spring 2021. We also found that *B. bassiana*, can persist in California orchard soil. In year 2 (fall 2020 -spring 2021) we will

continue to build on these previous studies and we are also conducting a citizen science study to determine when olive fruit fly larvae drop out of infested fruit in the fall to pupate in the soil.

### **Progress:**

*Objective 1:* We proposed to evaluate efficacy of using commercially available insect pathogenic fungi to control overwintering olive fruit fly, *B. oleae*, populations in the field by applying the fungal product identified from year 1 (Mycotrol) at two field sites. We planned on spraying twice, once in fall 2020 to target the overwintering larvae and a second time in spring 2021 to target emerging adults. However, based on preliminary lab results obtained earlier this year (Objective 1, year 1) we may only need to spray once in the spring. We are currently validating these results with additional data replication and expect to obtain our results within a few weeks. Emily Symmes our UCCE collaborator resigned in spring 2020 so we are in the process of identifying another collaborator and finding new field sites nearer our new collaborator. At this time, we do not anticipate that this will delay our proposed experimental plans. We will also be conducting the second year of the cage study that was begun in year 1 (fall 2019 - spring 2020). In year 1 we had low OLF emergence which was likely due to both high natural mortality of OLF larvae and the inability of the project team to infest cages earlier in the fall. The project team had difficulty in field-collecting enough larvae from which adults could be obtained to produce sufficient F1 larvae to infest the cage field trial before the start of rainfall and cooler temperatures that are the cues for soil infestation by a natural population. As a result, the infestation of soil cages occurred at later than optimal timing. This year we have already started our OLF colony and we are planning on infesting soil cages with more larvae than in year 1 and initiating the infestation as much as a month earlier so that timing will coincide as much as possible with when larvae drop out of infested fruit naturally in the field (see objective 3).

*Objective 2:* We proposed evaluating the capacity of insect pathogenic fungi to persist in the soil in olive orchards in California. In year 1 (fall 2019 – spring 2020), we tested the persistence of Mycotrol and Met 52 when applied to field sites in the fall and took and processed over 300 soil samples. We found that *Beauveria* (the active ingredient in Mycotrol) can persist in soil for at least two months after application and found both *Metarhizium* (the active ingredient in Met52) and *Beauveria* were present in field plots at the end of the study in March. This year we will repeat this study and will test the persistence of Mycotrol when applied in the spring to target emerging adults.

*Objective 3:* We proposed determining when olive fruit fly larvae would drop out of infested fruit in the fall. Originally, we planned to use metal baking sheets that would be placed under trees to catch larvae falling from infested fruit but in preliminary trials in fall 2019 we found that predators would sometimes eat the larvae before they could be counted. So instead, in fall 2020 we are using large mesh sleeve bags that are placed over infested olive branches and which can be easily opened by participants to check for dropped larvae. We have distributed a total of 12 traps to 5 participants located in the Orland/Corning area and Napa/Sonoma region. Our participants include Cindy Kron (UCANR IPM advisor), a PCA, an olive grower and other stakeholders. We have also set-up 8 traps on olive trees located on the UC Davis campus which we are monitoring. We will obtain data from this experiment as soon as the fly larvae begin to drop out of infested fruit this fall.

### **Dissemination of research results**

Due to Covid-19 were unable to present at this fall's CAPCA conference since the organizers finalized speakers earlier than usual this year. We are however on their list and will present our results at next year's annual CAPCA conference. We had also planned to present our results at UC Cooperative Extension olive meetings this past year, however two of our UCCE collaborators, Dani Lightie and Emily Symmes, have resigned so grower meetings that they would normally have been held did not occur this year. We are coordinating an effort to put together an olive newsletter this

winter in collaboration with remaining UCCE advisors, and plan to summarize our results and present them in this way.

**Interim Report – 10/2020**  
**California Olive Committee**

**I. Project Title:** Epidemiology and management of olive knot caused by *Pseudomonas savastanoi* pv. *savastanoi*  
**PI:** Dr. J. E. Adaskaveg      **Cooperating:** H. Förster and D. Thompson

**RESEARCH OBJECTIVES**

- 1. Evaluate new bactericides, potential enhancers of copper activity, food additives, GRAS sanitizers, and other experimentals against *Psv*.** In laboratory direct exposure assays, nisin and  $\epsilon$ -poly-L-lysine inhibited growth of *Psv* at selected rates and exposure times. Low rates and exposure of 30 min. were highly effective in reducing the pathogen concentration by 5-log. Again, the activity of these food preservatives was enhanced in mixtures with EDTA. Additionally, a capric/caprylic acid mixture (Dart) and a formulation of essential oils (ET-91) also showed in vitro toxicity. Several greenhouse and field efficacy studies were conducted using new bactericides by themselves or in selected mixtures, and efficacy was compared to copper, Kasumin, and Kasumin-copper mixtures. As in previous years, differences in efficacy were observed for protecting lateral wounds, artificially created leaf scar wounds (leaves were pulled off), and natural leaf scars. Overall, Kasumin and Kasumin-copper continued to be highly effective on lateral injuries and leaf scars. Copper mixed with dodine (Syllit) and Kasumin mixed with Syllit were highly effective. Oxytetracycline (Mycoshield, FireLine) mixed with Dart was highly effective in most trials but was consistently highly effective when mixed with copper for protecting infection of lateral wounds and leaf scars. Mixtures of nisin,  $\epsilon$ -poly-L-lysine, and lactic acid or of  $\epsilon$ -poly-L-lysine with Dart were mostly highly efficacious on both types of wounds. We are currently working with a registrant interested in the food preservatives nisin,  $\epsilon$ -poly-L-lysine, and lactic acid. This company is currently formulating the active ingredients into agricultural products with UV-protection and adjuvants to improve residual activity. Therefore, we will continue our efforts in making oxytetracycline and the antibacterial food preservatives that all have high in vitro toxicity more consistently effective. Among three essential oil formulations that were evaluated on the three types of wounds, one (Thymox) provided high efficacy on natural leaf scars only.
  - 2. Continue to support the registration of the antibiotics kasugamycin and oxytetracycline**  
Registration of oxytetracycline (Mycoshield, Fireline) is proceeding with EPA, and the two registrants were expecting full registration in 2020. EPA, however, delayed the review of oxytetracycline due to COVID-19, and the PRIA date was changed until fall of 2021. IR-4 completed the repeat residue studies with kasugamycin in the fall of 2019 and submitted the registration with approval of the registrant (UPL) to EPA in August 2020.
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**II. Project Title:** Evaluation of new fungicides for control of olive leaf spot

**PI:** Dr. J. E. Adaskaveg      **Cooperating:** H. Förster and D. Thompson

**RESEARCH OBJECTIVES**

- 1. Evaluate the performance of new and older fungicides in field trials and application timing of selected treatments.** Dithiocarbamate (ziram - FRAC Code or FC M3), chlorinated hydrocarbon (chlorothalonil - FC M5), polyoxin (polyoxin-D - FC 19), guanidine (dodine-FC U12, and organo-tin (tri-phenyl-tin - FC 30) compounds as well as a DMI/anilinopyrimidine premixture (difenoconazole/cyprodinil - FC 3/9) and a tank mixture of dodine and polyoxin-D are under evaluation in two field trials in Glenn and Sutter Co. and were compared to copper as a standard treatment. Treatments were applied in the fall (Nov.) and winter (Feb.) and were evaluated in April/June 2020 for peacock spot. Data are currently being statistically analyzed and summarized. Dodine (Syllit), difenoconazole/cyprodinil (Inspire Super), and chlorothalonil (Bravo) were highly effective. Polyoxin-D (Ph-D) was also highly effective again in our 2019 and 2020 trials, and UPL has agreed to add olive to the fungicide label. Because Ph-D is a biopesticide, it is exempt from tolerance and thus, no residue studies are needed. Dodine has European tolerances and IR-4 is petitioning EPA through the Chemistry Science Advisory Council (ChemSAC) process to register the fungicide on olive without conducting residue studies since rates and tolerances are established in the EU. We prepared the request and justified the need. This research is ongoing.
- 2. Evaluate new fungicides for their in vitro activity.** We are attempting to determine the in vitro activity of selected fungicides that are effective in field trials. This is very challenging because of the difficulty in

getting isolates to grow on laboratory media and because the fungus has an extremely slow growth rate. These factors prevent us from using the spiral gradient and direct agar assays. Additionally, the fungus does not sporulate continuously on leaves and at only in specific seasons winter and early spring. Spore germination assays in the presence of fungicides will need to be developed and evaluated.

- 3. IR-4 GLP Studies.** We have reviewed protocols and we are assisting in field studies that are ongoing. Two fungicides, Ziram and Inspire Super, are currently in the system and GLP field residue studies are being conducted for both fungicides in 2020. The fungicide premixture of azoxystrobin and difenoconazole (Quadris Top) was nominated and approved as an A priority at the 2020 IR-4 Food Use Workshop. We will assist in developing protocols and in field studies in 2021 for this latter fungicide. The registrant for tri-phenyl tin (Super Tin) contacted us, and we conducted field trials in 2019/2020 on olive. The EPA, however, has placed a “red light” restriction with no additional registrations for the fungicide in the United States. This was discussed at the Food Use Workshop in September 2020. Thus, registration of Super Tin will not be pursued for olive or any other crop based on EPA concerns.

**\*\*\*\*\* INFORMATION \*\*\*\*\***

<b>TOPIC</b>	<b>LEADERS</b>	<b>AMOUNT</b>
Timing Ethylene Applications as a Function of Heat Unit Accumulation	Louise Ferguson Giulia Marino	\$24,470
Managing Alternate Bearing in Olive with PGRs and Pruning	Carol Lovatt Elizabeth Fichtner	\$27,230
Combining Trunk Shaking and Canopy Shaking for a Highly Efficient, Low-Cost Olive Harvester-Part 2	Reza Ehsani Louise Ferguson	\$69,997
Precise Water Management Strategies for Table Olive Orchards in California	Giulia Marino Louise Ferguson	\$54,303.42
Epidemiology and Management of Olive Knot Caused by Pseudomonas Savastanoi pv. Savastanoi	J.E. Adaskaveg	\$31,650
Management of Foliar Diseases of Olive- A. Olive Knot and B. Evaluation of new fungicides for control of olive leaf spot	J.E. Adaskaveg	\$10,000
Characterization of Olive Fruit Abscission Zone in Response to Ethylene Applications and as a Function of Developmental Stage	Georgia Drakakaki	\$64,260
Southern San Joaquin Valley Olive Fruit Fly Monitoring Project	Jim Stewart	\$9,950
Sacramento Valley Olive Fruit Monitoring Project	Ernie Simpson	\$6,500
<b>Total</b> * budget estimate; actual budget pending on results		\$298,360.42

<b>Grant Name</b>	<b>Funds Requested</b>
Increasing Demand for Domestic California Ripe Olives by sharing Farmers' Stories and Recipes with Consumers	\$450,000
Cost Study on the Transition from Traditional to Modern Acreage x Modern Acreage Model Orchard	\$99,133

## California Olive Committee Research Priorities for 2021

The California Olive Committee Research Subcommittee met and established the 2021 research priorities. These priorities must be conducted only on Manzanillo and Sevillano ripe olive varieties. The priorities are:

- Mechanical Harvesting for high density orchards and existing orchards
- Mechanical harvesting transition
- Cost study to determine which trees are convertible for trunk shaking
- Loosening Agents
- Management of black scale
- Management of olive knot
- Canopy Management
- Olive Fruit Fly Trapping
- Evaluation of drone technology and satellite imagery to measure canopy density and yields
- Olive DNA evaluation

## CALIFORNIA OLIVE COMMITTEE

### PROJECT PLAN/RESEARCH GRANT PROPOSAL

Workgroup/Department: Olive / Plant Sciences, UC Davis

Project Year : April 1, 2021 – March 31, 2022. Anticipated Duration of Project: 1 year  
(UC Davis Sponsored Programs Proposal # 21-1560)

#### **Project Title:**

**Timing Ethylene Applications as a Function of Heat Unit Accumulation.**

#### **Project Leaders:**

**Dr. Louise Ferguson:** Extension Specialist, Department of Plant Sciences, 2037 Wickson Hall, Mail Stop II, UC Davis, 1 Shields Ave., Davis CA 95616, (530) 752-0507 [Office], (559) 737-3061 [Cell], [LFerguson@ucdavis.edu](mailto:LFerguson@ucdavis.edu).

**Dr. Giulia Marino:** Extension Specialist, Department of Plant Sciences, 2037 Wickson Hall, Mail Stop II, UC Davis, 1 Shields Ave., Davis CA 95616, (530) 304-4509 [Cell], [Giumarino@UCANR.edu](mailto:Giumarino@UCANR.edu)

#### **Cooperators:**

**Dr. Georgia Drakakaki:** Professor, UC Davis

**Dr. Reza Ehsani:** Professor, UC Merced

**Dr. Richard Rosecrance:** Professor, Chico State University

**Mr. William H. Krueger:** Farm Advisor Emeritus

**Mr. Erick Nielsen:** ENE Inc., pruning and harvesting designer, fabricator and contractor.

Commodity: Olive Relevant AES/CE Project No.

Year Initiated: 2021 Current Funding Request: **\$24,470.00**

#### **Problems and Significance:**

Side by side trunk shaking ‘Manzanillo’ table olive harvester efficiency could be improved with an effective, reliable abscission compound that did not also produce excessive leaf loss. In the past 12 years we have investigated all the recent developments in Ethephon research. We tried buffering the ethephon with monopotassiumphosphate (MPK), marketed as HarvestVant®, (Birger et al 2008; Burns et. al. 2008) We tried the Goldental-Cohen et. al (2016) method of adding 0.3% ascorbic acid or 100 mM butyric acid to the standard 1500 PPM ethephon in 2016 and 2017. In both cases effects fruit removal force were erratic. As our years of spray trials have not yielded reliable results we are proposing a different approach.

All fruit growth is a function of heat. And all fruits have a specific “accumulated heat unit requirement to mature; Growing Degree Days; GDD. We propose to follow and characterize fruit development, primarily by measuring volume growth and dry weight, as it matures while simultaneously tracking the heat unit accumulation; this is called developing a phenology model. The value of a phenology model is that once a fruit’s growth as a function of heat has been determined; growth and maturity can be predicted by knowing how many more heat units need to be accumulated to achieve maturity. Hopefully, by using accumulated heat units to determine when an olive fruit is mature, and receptive to ethylene, we can better target when to apply ethephon. I have developed a model like this for pistachios that predicts kernel growth and hull split in six different cultivars. This model is now used to determine when to stop midseason deficit irrigation and to determine the optimum time to harvest

We propose to do this by monitoring temperature accumulation and olive fruit growth in two locations, and as maturity approaches, start testing fruit removal force. When the fruit removal force begins to decline we will start whole tree ethephon applications, and continue testing fruit removal force testing until fruit the fruit is judged ready for harvest. At that time the treated and control trees will be mechanically harvested with a trunk shaker, the mechanically harvested fruit submitted for grading and the remaining fruit gleaned to determine harvester efficiency of the ethephon treated and untreated mechanically harvested trees.

This experiment will be done in cooperation with two mechanically harvested orchards within cooperating experiments; Nickels Soils Laboratory with Rosecrance and Krueger’s pruning experiment and Reza Ehsani’s harvester prototype trials and in Corning with Giulia’s Marino’s irrigation experiment. In both locations a side by side trunk shaking pistachio harvester is now used for harvesting.

### **2021 Objectives: (April 1<sup>st</sup> – October 31<sup>st</sup> 2021)**

**Evaluate olive fruit growth as a function of accumulated degree days (DD) after full bloom above 45°F to determine:**

- 1. At what accumulated GDD fruit removal force starts to decline:
  - a. We are assuming this is when the abscission zone is starting to form.****
- 2. At what GDD accumulation applying ethephon is most effective.**
- 3. Demonstrating ethephon applied based on GDD accumulation increases trunk shaking harvester efficiency**

### **2021 Experimental Procedures:**

#### Orchards

Two orchards pruned for trunk shaker harvesting will be secured:

1. Nickels Soils Laboratory moderate density (202 tree/acre) orchard in Colusa County
2. Glenn County Orchard, 180 trees per acre, where Giulia Marino will be conducting an irrigation trial.

In each orchard 3 sets of 2 rows each will be selected in March 2021

#### Temperature Logging and Growing Degree Day (GDD) Accumulation Calculation

Data loggers that measure temperature accumulation will be installed in March before bloom.

At full bloom the loggers will start logging daily temperatures and Growing Degree Day (GDD) accumulation will be calculated as follows: (45°F as Tbase)

$$\text{GDD} = (\text{Tmax} + \text{Tmin})/2 - \text{Tbase}$$

When olives are ~ 1cm in length, 3 sets of 100 olives/row will be collected weekly:

- Average size by volume will be determined by water displacement
- Dry weight will be determined by oven drying

#### Fruit Removal Force (FRF) Measurements;

When olive volume growth starts to slow fruit removal force (FRF) will be done tested on 100 olives/row:

#### Ethephon Treatment

When fruit removal force starts declining, and/or fruit shows color, treatments will start:  
3 rows x 3 trees = 9 trees per treatment and control each, sprayed to drip @ 100 GPA rate

1. 1500 PPM Ethephon + 4% MPK and 0.25% surfactant\*
2. Water control and 0.25% surfactant
  - Selected this treatment in discussions with Israeli and Australian colleagues

The spray treatments will be repeated at 3 day intervals; we estimate no more than 3-4 total spray timings.

When the FRF drops for 3 samplings in a row (over 6 days), or by 50% in any one of the spray times we will harvest; we anticipate this will happen in mid-September to October.

#### Harvesting

At the Nickels Soils Laboratory orchard we may have the option of two harvesters:

- ENE pistachio trunk shaking harvester
- Reza Ehsani's prototype trunk + canopy contact harvester

At the Corning orchard in Giulia Marino's irrigation experiment it will be a trunk shaking harvester.

At harvest, harvested weight of 3 tree sets will be combined, weighed and one sample for grading

Trees will be hand gleaned and fruit weighed but not graded

Harvester efficiency of ethephon sprayed versus control trees will be calculated as:

$$\text{Efficiency} = \frac{\text{Mechanically harvested (lb)}}{\text{Manually harvested (lb)} + \text{Mechanically harvested (lb)}} \times 100$$

### Statistical Analysis:

An Analysis of Variance with and LSD means separation test will compare:  
Harvester efficiency for treated versus control trees for:

- among the sequential spray dates to determine at which GDD accumulation the ethephon spray was more effective.

### After Harvest:

The treated tree sets will be evaluated for leaf drop at harvest and in March. The trees will be rated visually for leaf drop on a 1-3 scale: 1= none, 2 = visible, 3 = severe.

1. Ten shoots per tree will be counted for % leaf drop: > 25% will be considered unacceptable.

Data will be analyzed using ANOVA with an LSD means separation.

### **Desired Result:**

The 1500 ppm ethephon treatment will decrease fruit removal force, increase harvesting efficiency to at least 90% without producing leaf loss over 25%.

### **References:**

Birger, R., Abd-ElHadi, F., Ronen, A., Cohen, E., Ankorion, Y., Najjar, A. and Moreno, J. (2008). Olive Harvestant, a new Harvest-Aid Formulation for Improving Fruit Abscission and Mechanical Harvesting. *Acta Hort.* 791, 257-263

DOI: 10.17660/ActaHortic.2008.791.36

<https://doi.org/10.17660/ActaHortic.2008.791.36>

Burns, J.K., L. Ferguson, K. Glozer, W.H. Krueger, and R.C., Rosecrance. 2008. Screening fruit loosening agents for black ripe processed table olives. *HortScience* 43(5):1449-1453.

Goldental-Cohen, S, I.B.Y. Mani, B. Avidan, S. Lavee, G. Ben-Ari. 2016. Anatomical and molecular differences between the olive fruit and leaf abscission zone enable development of a selective abscission compound. *Abstract: Int. Soc. Of Hort. Sci.: 8<sup>th</sup> Int. Olive Symp. Oct. 10<sup>th</sup> – 14<sup>th</sup> 2016 Split, Croatia. P. 42.*

**BUDGET REQUEST: 2021**

Budget Year: 2021

Funding Source: COC

**Data Collection: \$19,276**

Assistant Specialist Step II at 25% with starting base of \$55,500.

Benefits rates are 38.1% for 3 months and 39.2% for 9 months and are derived from the UC Davis composite benefits rate schedule.

Starting march 1st his employee will be responsible for instrumenting with Onset data loggers and starting at bloom monitoring two experimental table olive orchards, one in Orland (Glenn County) and one in Arbuckle (Colusa County) for heat unit accumulation above 7.5°C (45°F). The employee will collect weekly temperatures, calculate heart unit accumulation, and biweekly collect samples for volume and dry weight increase. A month before the projected harvest date the employee will apply abscission treatments, perform pull force tests, evaluate fruit quality and leaf abscission and assist in evaluating abscission chemical efficacy in associated mechanical harvesting trials.

**Sub 1 19,276.00**

**Travel: 2,269.00**

25% of UC Fleet Services ¾ ton double cab truck @ \$712.83/month and average 1000 miles per month for 6 months + 200.00/month for gas

This truck will be used for weekly trips to the two experimental orchards.

**Sub 2. 2,269.00**

**Supplies, Equipment: 500.00**

Supplies: bags, tags, tape, buckets, tarps, safety equipment

**Sub 3 500.00**

**Indirect Costs: 2,425.00**

Indirect costs are based on 11.0% of total direct costs.

**Sub 4.** **2,425.00**

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**TOTAL BUDGET REQUEST** **24,470.00\***

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- This experiment will be done in cooperation with the following trials:
- Dr. Giulia Marino’s irrigation experiment
  - Will be sharing dataloggers for temperature accumulation
- Dr. Reza Ehsani’s mechanical harvesting experiment
  - Will be testing his harvester with treated trees and designing pruning treatments
- Rich Rosecrance and Bill Krueger (ARI funding through CSU Chico)
  - Will be sharing harvester and evaluating pruning treatments
- Dr. Georgia Drakakaki’s abscission zone studies
  - We will be collecting her samples

**Scope of Work**

Drs. Louise Ferguson, Giulia Marino and Asst. Specialist Emily Santos:

Responsible for overall coordination and execution of this of the project and data collection. This will include securing the experimental orchards, pruning the orchards, collecting temperature data, spraying the treatments, doing the pull tests, conducting the mechanical harvesting, delivering the samples to the olive receiving facility, hand gleaning, evaluating fruit removal force, harvester efficiency and leaf drop, and analyzing the data and writing the final report.

**Approved by:**

UC Davis Sponsored Programs Proposal # 21-1560

Title: Scheduling Table Olive Abscission Sprays as a Function of Temperature

Sponsor: California Olive Committee

Approved 10/20/2020

Proposal Deadline: 10/31/2020

Sarah Smith

Contracts and Grants Analyst – Proposal Team

Office of Research, Sponsored Programs

University of California, Davis

(530) 754-8192

Email: [susmith@ucdavis.edu](mailto:susmith@ucdavis.edu)

**UNIVERSITY OF CALIFORNIA DAVIS**

  
\_\_\_\_\_  
Originator's Signature

10/30/2020  
Date

Agricultural Experiment  
Station

  
\_\_\_\_\_  
Department Chair

10-30-2020  
Date

*Elizabeth J. Ferguson*  
\_\_\_\_\_  
Liaison Officer

10/30/2020  
Date

## CALIFORNIA OLIVE COMMITTEE

### PROJECT PLAN/RESEARCH GRANT PROPOSAL

**Project Year:** 2021

Anticipated Period of Performance: year 2 of 3 years requested

**Project Title:** Managing Alternate Bearing in Olive with Plant Growth Regulators (PGRs) and Pruning

**Project Leaders:** Elizabeth Fichtner and Carol Lovatt

EF-Farm Advisor, Orchard Systems, Cooperative Extension, 4437 S. Laspina St., Tulare, CA 93274; Phone: 559-684-3310; Fax: 559-685-3319; Email: [ejfichtner@ucanr.edu](mailto:ejfichtner@ucanr.edu)

CL-Professor of Plant Physiology, Emeritus & Professor in the Graduate Division, Botany and Plant Sciences-072, UC Riverside, CA 92521-0124; Phone: 951-827-4663; Fax: 951-827-4437; Email: [carol.lovatt@ucr.edu](mailto:carol.lovatt@ucr.edu)

**Cooperators:** Kurt Schmidt, Lindcove Research and Education Center, 22963 Carson Avenue, Exeter, CA 93221; Phone: 559-592-2408, ext. 153; Email: [krschmidt@ucanr.edu](mailto:krschmidt@ucanr.edu)

Commodity: Olive

Relevant AES/CE Project No.: 4556-H

Year Initiated: 2020

Anticipated Duration of Project: 3 crop years

2021 request: \$27,230

**Problem and Previous Research Accomplishments:** ***Problem.*** Alternate bearing (AB), production of a heavy "on-crop" (high yield, ON-trees) followed by a light "off-crop" (low yield, OFF-trees), occurs in perennial fruit and nut crops, as well as forest species (where it is called "masting"). For tree fruit crops, alternating high and low yields cause significant economic problems. In ON-years, trees produce a large number of small size fruit with reduced commercial value. In OFF-years, a significant proportion of the fruit are too large, resulting in reduced economic value, and large fruit of OFF-crop trees turn black earlier in the season further exacerbating the problem of too few commercially valuable size fruit in OFF-crop years to provide growers with a good income. For olive, the ON-crop takes longer to mature, attain size and accumulate oil. The delayed harvest further reduces floral intensity the following spring. It is important to note that if AB is more or less industry-wide, the lack of fruit in the OFF-crop year and large number of small fruit in the ON-crop year have a negative economic impact on every step in the production chain from farm to consumer, including orchard management, harvesting, packinghouse operation, manufacture of value-added products, marketing, and consumer prices, which jeopardizes the stability and sustainability of tree-crop commodity-based industries such as olive. The major factor initiating AB is climate. An adverse climate event (high or low temperature, excessive winter rain causing soil hypoxia etc.) that ultimately reduces yield to an OFF crop initiates AB. Conversely, when climate is optimal during flowering and fruit set such that natural flower or fruit thinning fails to occur, an ON crop results, which initiates AB. Thus, there is a reoccurring need for a management strategy to mitigate AB. ***Previous Research Accomplishments.*** Our research confirmed that the ON crop of fruit inhibits summer vegetative shoot growth, reducing the number of nodes that can bear floral buds the following spring (first reported by Sibbett, 2000) and was the first to document that the ON crop causes bud abscission

of existing putative floral buds through harvest, inhibits the transcription of genes necessary for flower development even after harvest, and reduces bud break in spring following the ON-crop (Fichtner and Lovatt, 2018; Fichtner et al., 2017). For ON-crop trees, our research results documented that the severity of these effects is greater for bearing shoots, the majority of shoots on ON-crop trees, than non-bearing shoots. Further, our research results demonstrated that plant growth regulator (PGR) treatments using a cytokinin and/or an auxin transport inhibitor significantly increased return bloom on non-bearing shoots, but were not effective on bearing shoots (Fichtner and Lovatt, 2018; Fichtner et al., 2017). Only non-bearing shoots on ON-crop trees, which are in the minority, contribute a significant number of inflorescences to spring bloom following the ON-crop year. Thus, non-bearing shoots produce the crop following the ON year. Taken together, these results provide strong evidence that increasing the number of non-bearing shoots on ON-crop olive trees is required to increase return bloom and yield the following year. **Accomplishments during the last 4 years.** Our research during the last 4 years tested the efficacy of a PGR flower thinning treatment (naphthaleneacetic acid [NAA], ALCO<sup>®</sup> Olive Stop<sup>™</sup>; AMVAC Corp., registered for use on olive) at full bloom compared to mechanical pruning (hedging) after fruit set (28 days after full bloom) and untreated ON- and OFF-crop control trees. Trees in all treatments were topped to approximately 14 feet each year. In addition, a comparison was made to determine whether trees should be pruned on one side of the tree and then the other side annually or every other year. **Treatment effects on return bloom 2017-2020.** Examination of the bloom estimates prior to treatment (Table 1) and resulting yields (Table 2) for the four years of the research confirms that thinning treatments (NAA or pruning) should not be applied if the pre-treatment estimated bloom on the side of the tree that will be left untreated in the current year is less than 2.0 on a scale from 0 to 3, as the resulting total yields are too low. Estimating bloom is not onerous, requiring only a quick walk or drive through a block. Thus, flexibility in the application of a fruit thinning strategy will be required rather than strict adherence to a prescribed pattern of treatment. This is especially true when a climate event initiates a new alternate bearing pattern as in 2019, when all trees were “ON” independent of the previous year’s crop load. Treatments should have been applied to the ON crop in 2019, but were scheduled for 2020 and applied then. Yield results using NAA versus pruning have been fairly similar, except for the application NAA in Treatment 2 in 2020 (Table 2). We expected the yield for trees treated with NAA on one side of the tree and then the other side every other year to be similar to trees pruned on one side of the tree and then other side every other year (Table 2). In 2020, the Olive Stop NAA might have over thinned in response to three days of day-time temperatures  $\geq 95$  °F that occurred three days after application. This possibility is behind the registration of the new NAA product by AMVAC, Mandolin<sup>®</sup>, that is less sensitive to high temperatures and thus, less prone to over-thinning. Mandolin<sup>®</sup> will replace Olive Stop<sup>®</sup>, which will no longer be available for use in commercial olive production. Thus, testing Mandolin<sup>®</sup> over the next two years is imperative. It is anticipated that growers would interchange the use of NAA with pruning since fruit and nut tree must be pruned to control tree height to facilitate harvest and keep the rows open for orchard management, to maintain uniform annual yields, to mitigate negative effects of a heavy ON crop when alternate bearing occurs, to increase fruit size, and to open the canopy for light penetration -- No light, no flowers! **Treatment effects on yield 2017-2020.** In all cases, treatments were first applied to ON-crop trees. All trees in the experiment have now produced two ON crops and two OFF crops (Table 2). All treatments have reduced the severity of alternate bearing compared to the ON- and OFF-crop control trees based on Alternate Bearing Index (ABI). For each 2-year ON-/OFF-yield cycle, ABI was calculated as (year 1 yield – year 2 yield)/ (year 1 yield + year 2 yield), in which yield is total kilograms of fruit per tree and

the difference in yield between years 1 and 2 is expressed as an absolute value. An ABI of zero means no alternate bearing, whereas an ABI of one is complete alternate bearing, i.e., crop one year, no crop the other year (Pearce and Dobersek-Urbanc, 1967). From 2017 to 2020, ABI decreased for treated trees from an average of 0.75 to 0.55. The average for the untreated ON-/OFF-crop control trees for this period only decreased to 0.68. The ABI for trees treated every other year is significantly lower than those treated annually for the last 2 years of the research (2018-2019 and 2019-2020) ( $P < 0.0001$ ). Thus, there is less variation in annual yield when trees are treated on one side and then the other side every other year than annually. **Treatment effects on fruit size and quality 2017-2020.** We have previously reported significant benefits on fruit size and yield of green-colored fruit (prevention of fruit blackening) in response to the fruit thinning treatments. An additional benefit of our research was the documentation of the strong inverse relationship between the proportion of black and partially black fruit per tree at harvest and total yield per tree ( $r = - 0.60$ ;  $P < 0.0001$ ) first observed by Dr. Fichtner, with OFF-crop control trees having the largest proportion of black and partially black fruit and the fewest green fruit (only 54%) ( $P = 0.0003$ ). Conversely, the proportion of fruit that remained green through harvest increased in parallel with total yield per tree ( $r = 0.60$ ;  $P < 0.0001$ ) with the majority (90%) of the fruit remaining green on ON-crop control trees and NAA and pruned trees having 81% and 75% green fruit, respectively ( $P = 0.0003$ ). The 2020 harvest data confirmed this result. The ON-crop control trees and trees treated with NAA or pruned on one side of the tree and then the other side every other year had a significantly greater percent green fruit ( $> 83\%$ ) compared to OFF-crop control trees (50%) and trees treated with NAA (59%) or pruning (66%) one side of the tree and then the other side annually ( $P < 0.0001$ ). Thus, a greater proportion of green fruit might be another benefit derived from fruit thinning strategies applied to alternating sides of the tree every other year to increase return yield following the ON-crop year. Having more uniform yields also stabilizes fruit size, reducing the potential for large numbers of petite or extra-large fruit. In Table 4, it can be seen that 2-year cumulative yields (2019 + 2020) of medium and large size fruit, respectively, for trees treated with NAA or pruning on one side of the tree and then the other side every other year are among the best. **Conclusion.** Non-bearing shoots, as opposed to bearing, shoots, contribute the majority of inflorescences and crop following an ON crop. Thus, in an ON-crop year it is necessary to create non-bearing shoots by removing fruit with NAA or pruning. Reducing crop load with NAA or pruning one side of the tree and then the other side is best done every other year, not annually and not on a rigid schedule. The crop thinning treatments should not be carried out if the bloom intensity is low (OFF) on the side of the tree to be left untreated and should be used out of sequence to treat an ON-bloom/ON-crop when alternate bearing is reinitiated. With the resolution of the question of how frequently to use NAA or prune, the next goal is to combine fruit thinning strategies with the cytokinin-PGR (natural product that does not require registration) that proved effective on non-bearing shoots in our earlier research for increasing summer vegetative shoot growth, number of floral buds for next spring's bloom, spring bud break, inflorescence number and fruit size to compensate for crop loss due to fruit thinning treatments necessary to even out annual yield in an alternate bearing orchard so that 2-year cumulative yield of commercially valuable size fruit is greater than the sum of the ON-/OFF-crop yields in an alternate bearing cycle. The 2-year cumulative yields for large and medium size fruit presented in Table 4 suggest that this goal is attainable.

**Research Goals, Objectives, Benefits and Anticipated Outcomes:** The goals of this research are the following: Goal 1 - to even out AB so there is a good crop annually by switching crop production from one side of the tree to the other side of the tree every other year; Goal 2 - to

sustain production each year at a level equal to approximately 70% of the average ON-crop yield for an orchard, which will improve fruit size and increase annual yield of commercially valuable size fruit, and the proportion of green fruit (both aspects of fruit quality are crop load dependent), such that 2-year cumulative yield of commercially valuable size fruit is greater than the sum of the ON-/OFF-crop yields in an alternate bearing cycle; and Goal 3 - to provide growers with a means to mitigate AB when it reoccurs so growers have a stable and good income annually. These goals will be achieved using ‘Manzanillo’ olive trees in a block, which includes ‘Barouni’ olive trees as the pollenizer planted at a ratio of one to ten, at the Lindcove REC in Exeter, CA. All trees are topped annually to maintain uniform tree height. All trees were skirted in 2020.

**2021-2022 Objectives.** *Objective 1* - To reduce crop load (total number of fruit per tree) and increase the number of non-bearing shoots to maintain uniform high yields of commercially valuable size fruit by using the best crop thinning strategies identified in our previous research - NAA and pruning applied to one side of the tree and then the other side every other year. To meet this objective, we will test the new AMVAC NAA product, Mandolin<sup>®</sup>, which will replace Olive Stop<sup>®</sup>. Mandolin<sup>®</sup> will be applied according to the manufacturer’s instructions (**Note:** the directions for using Mandolin<sup>®</sup> are very precise and easy to follow, with instructions on how to adjust the spray rate to accommodate delayed application). To meet this objective, we will also remove fruit by pruning (mechanical hedging) one side of the tree and then the other side every other year. *Objective 2* – To maintain uniform high yields of commercially valuable size fruit we will combine the best crop thinning strategy using NAA and pruning described under Objective 1 with a foliar application of the natural cytokinin PGR product (registration for use on olive is not required) identified in our previous research as effective on non-bearing shoots for increasing summer vegetative shoot growth, which increases floral bud number, spring bud break, inflorescence number and fruit size (Fichtner and Lovatt, 2018; Fichtner et al., 2017). Applications will be made just prior to summer vegetative shoot growth and again just prior to spring bud break. (**Note:** the summer application is not made in a low bloom/ low yield year). The results of treatments described under Objectives 1 and 2 will be compared with untreated ON- and OFF-crop control trees. The experiment utilizes a randomized complete block design with 16 individual tree replications per treatment using ‘Manzanillo’ olive trees in a block, which includes ‘Barouni’ olive trees as the pollenizer planted at a ratio of one to ten, at the Lindcove REC in Exeter, CA. Treatments will be applied on a flexible schedule to accommodate high temperatures near bloom, which is easy to do with AMVAC’s new NAA product, Mandolin<sup>®</sup>. The treatment schedule will be modified to best manage light or heavy blooms when AB reoccurs. Total yield and fruit size distribution as kg/tree will be determined and calculated as number per tree; fruit quality will be evaluated for the proportion of green, partially green, partially black and black fruit. Alternate bearing index will be determined. A final cost benefit analysis will be calculated. **Benefits of the proposed research.** (1) In our experiment, the Mandolin<sup>®</sup> application is 12 days after full bloom and pruning is 28 days after full bloom. This enables growers to evaluate bloom intensity or the crop set by their trees before deciding to treat with NAA or prune. (2) Reducing crop load on only one side of the tree every other year reduces the negative effect on final yield compared to treating one or both sides of the tree in a given year. (3) Since the treatments increase the number of non-bearing shoots per tree, they will improve the efficacy of PGR treatments that increase summer vegetative shoot growth, floral bud number, floral bud retention and spring bud break to increase floral intensity and yield following the production of the ON crop and also the efficacy of PGR treatments designed to improve fruit set or size or delay fruit blackening (Fichtner and Lovatt, 2018; Fichtner et al., 2017). (4) In addition to shifting fruit into more commercially valuable size categories, evening out alternate

bearing will ensure a greater proportion of green fruit (reduced proportion of black and partially black fruit) at harvest, which in some years is significant (2017). Both fruit size and percent green fruit are crop load-dependent, with OFF-crop trees producing fruit that are too large and have a greater proportion of black or partially black fruit.

### **Anticipated Outcomes.**

- We will confirm that treatments should not be applied when the side of the tree to be left untreated has a bloom estimate less than 2 on a scale from 0 to 3.
- Results thus far suggest that NAA inflorescence removal and fruit removal by pruning (hedging) typically resulted in similar return bloom intensity and return yield. We will determine whether Mandolin<sup>®</sup>, which has a slightly later application time (12 days) than Olive Stop provides similar results to pruning and can be interchanged with pruning to accommodate tree canopy management.
- We learned that pruning at the end of June is too late to stimulate summer vegetative shoot growth to increase return bloom and yield. In addition, we learned that pruning at the end of June did not reduce fruit size; (for trees pruned at the end of June, average fruit size was large)). We learned that the end of May (28 days after full bloom) is optimal and still gives growers the opportunity to evaluate their potential crop load to make a decision to prune or not to prune in a given year. It protects growers in years when bloom is heavy but resulting fruit set is light.
- We will have additional data establishing the year-to-year variability in yield encountered using Mandolin<sup>®</sup> NAA versus pruning for crop thinning.
- We will obtain addition data to confirm data that reducing crop load on alternate sides of the tree should be done every other year to sustain good yields, optimal fruit size, greater percentage of green fruit and grower income annually.
- The harvest data will quantify the effects that removing fruit on one side of the tree and then other side every other year in combination with the natural cytokinin-PGR product have on average fruit size, fruit size distribution (pack out), proportion of green versus black fruit, and crop value.
- Thus, the data will document whether efficacy of the best crop thinning strategy using NAA or pruning is improved by combining it with the natural cytokinin-PGR product.
- The data will quantify the efficacy of the treatments to reduce the severity of alternate bearing (Alternate Bearing Index; ABI) in ‘Manzanilo’ olive orchards in California and improve fruit size and fruit color and net dollar return.
- We anticipate that one or more of the strategies being tested will successfully mitigate alternate bearing and increase 2-year cumulative yield of commercially valuable size fruit and grower income and thus, will be a strategy that can be successfully employed starting with the ON-crop each time alternate bearing is initiated by an adverse climate event or cultural problem that results in an OFF crop, which is then followed by an ON crop, and then be used on a regular basis to maintain high uniform annual yields of commercially valuable size fruit.

### **Select References:**

Chao, Y.Y. 2014. Alternate Bearing in Olive (*Olea europaea* L.). MS Thesis. University of California, Riverside, CA.

Fichtner, E., Lovatt, C.J. 2018. Alternate bearing in olive. *Acta Hort.* 1199:103-108.  
doi:10.17660/ActaHortic.2018.1199.17

Fichtner, E.J., Y.Y. Chao, L. Ferguson, J.S. Verreynne, L. Tang and C.J. Lovatt. 2017. Repeating cycles of ON and OFF yields in alternate bearing olive, pistachio and citrus trees — *Different mechanisms, common solutions*. *Acta Hort.* (in review)

Pearce, S.C. and S.Dobersek-Urbanc. 1967. The measurements of irregularity in growth and cropping. *J. Hort. Sci.* 42(3):295–305.

Sibbett, S. (2000). Alternate bearing in olive trees. *California Olive Oil News*. 3(12),1

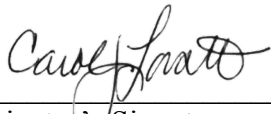
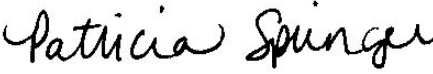

**BUDGET REQUEST: (Carol J. Lovatt)**

Budget Year: 2021

Funding Source: COC

<b>Labor:</b>	<b>(Line 1)</b>	<b>\$6,460</b>
Salary: T Khuong @ \$66,000/yr. x 5% = \$3,300; Lab Asst. 1 @ \$17.60/hr. x 50 hr. = \$880	\$A	\$4,180
Benefits: TK= \$3,300 x 51% = \$ 1,683 Lab Asst. 1 = \$880 x 67.80% = \$597	\$B	\$2,280
<b>Subtotal 1</b>	<b>Line 1 subtotal</b>	<b>\$6,460</b>
<b>Supplies, Equipment:</b>	<b>(Line 2)</b>	<b>\$8,550</b>
Supplies: <i>(be specific. Examples include tape, tags, buckets, traps, safety, chemicals, etc.)</i>	\$C	\$0
Equipment: <i>(be specific. Examples include balances, meters, devices, etc.)</i>	\$D	\$0
Individual contractors: Recharge to Lindcove REC – use of olive orchard, irrigation, weeding, pruning, pest control, application of PGRs = \$8,550 (actual under new rates; includes harvest)	\$E	\$8,550
<b>Subtotal 2</b>	<b>Line 2 subtotal</b>	<b>\$8,550</b>
<b>Travel:</b>	<b>(Line 3)</b>	<b>\$2,411</b>
Vehicle Use: 5 roundtrips to Exeter (520 mi x 5 = 2,600 mi x \$0.6014/mi = \$1,564; UCR vehicle Rental 10 days x \$47.268/day = \$473; \$125/3 nights + meals = \$375	\$F	\$2,411
Meeting attendance: <i>(be specific. anticipated travel to meetings such as COC meetings, professional society meetings)</i>	\$G	\$0
<b>Subtotal 3</b>	<b>Line 3 subtotal</b>	<b>\$2,411</b>
<b>Subcontracts: Elizabeth Fichtner</b>	<b>(Line 4)</b>	<b>\$7,893</b>
<b>Collaborator A: Elizabeth Fichtner</b>	\$H	\$7,893
<b>Subtotal 4</b>	<b>Line 4 subtotal</b>	<b>\$7,893</b>
<b>UCR Total</b>	<b>(Line 5)</b>	<b>\$17,421</b>
<b>UCR Overhead on \$17,249 @ 11% IDC</b>	<b>(Line 6)</b>	<b>\$1,916</b>
<b>(Total to primary PI – Carol Lovatt)</b>	<b>(Line 7)</b>	<b>\$19,337</b>
<b>TOTAL BUDGET REQUEST</b>	<b>Line 4+Line 7</b>	<b>\$27,230</b>

**PRIMARY PI SIGNATURE PAGE: UNIVERSITY OF CALIFORNIA**

 _____ Originator's Signature	<u>10/29/2020</u> Date
 _____ Department Chair/County Director	<u>10/29/2020</u> Date
<b>Krystene Carpenter</b> _____ Liaison Officer	 Digitally signed by Krystene Carpenter Date: 2020.10.29 16:25:53 -07'00' _____ Date

**SUBCONTRACT BUDGET REQUEST: (Elizabeth Fichtner)**

Budget Year: 2021

Funding Source: COC

<b>Labor:</b>	<b>(Line 1)</b>	<b>\$6242.93</b>
Salary ( <i>Junior Specialist at 9% FTE</i> )		\$4494.55
Benefits (38.9%)		\$1748.38
<b>Sub 1</b>		<b>\$6242.93</b>
<b>Supplies, Equipment:</b>	<b>(Line 2)</b>	<b>\$200.00</b>
Supplies: ( <i>be specific. general field supplies (flagging tape, pruners, buckets, gloves. etc)</i> )		\$200
<b>Sub 2</b>		<b>\$6442.93</b>
<b>Travel:</b>	<b>(Line 3)</b>	<b>\$667.80</b>
Vehicle Use: ( <i>Mileage from Tulare, CA to/from Modesto for COC meetings; 280 miles round trip @ \$0.535/mile. Request partial funds (\$200) toward attendance of Pomology Conference in Davis in March 2020. This is approximately 1/3 of the cost of attending the meeting; other costs would be contributed by walnut and pistachio accounts to share costs across main commodities that I serve. Ten roundtrips Tulare to Lindcove 600 miles x \$0.53 = \$318</i> )		\$667.80
<b>Sub 3</b>	<b>(Line 4)</b>	<b>\$7,110.73</b>
<b>UCD/ANR/UCR Overhead @ 11%</b>	<b>(Line 5)</b>	<b>\$782.18</b>
<b>Sub 4 (Total Subcontract)</b>	<b>(Line 6)</b>	<b>\$7,892.91</b>
		<i>(Add Line 6 to primary PI budget in subcontract section 'H' and 'I')</i>

**SUBCONTRACT SIGNATURE PAGE: UNIVERSITY OF CALIFORNIA**

*Elizabeth J. Fickner*

10/30/2020

Originator's Signature

Date

**Karmjot Randhawa** Digitally signed by Karmjot Randhawa  
Date: 2020.10.30 09:33:48 -07'00'

Department Chair/County Director

Date

*Elizabeth J. Fickner*

10/30/2020

Liaison Officer

Date

**Table 1.** Effects of crop load and two fruit thinning treatments, foliar application of the PGR NAA at full bloom and pruning after full bloom (June 26, 2017, May 30, 2018, May 31, 2019, and June 2, 2020) to one side of the tree and then the other side annually or every other year on 'Manzanillo' olive tree on estimated return bloom the following year in 2018, 2019 and 2020 prior to treatment. Data in bold red indicate bloom to be thinned in a specified year.

2017 <sup>z</sup>	2018	2019	2020	2018	2018	2019	2019	2020	2020
Treatment <sup>z</sup>				W/E	Avg.	W/E	Avg.	W/E	Avg.
1 OFF-crop control	ON-crop Control	OFF-crop control	ON-crop control	2.7a <sup>y</sup> /2.6a	2.7 a	1.3c/1.8cd	1.6 b	2.3a/2.6a	2.4 a
2 No treatment	NAA-East side of tree	No treatment	NAA-West side of tree	2.2a/ <b>2.3a</b>	2.3 a	1.8b/2.1bcd	1.9 b	<b>1.8bc</b> /1.8bc	1.8 bc
3 No treatment	Pruned-East side of tree	No treatment	Pruned-West side of tree	2.6a/ <b>0.4b</b>	2.6 a	1.9b/1.6d	1.8 b	<b>2.1ab</b> /2.3ab	2.2 ab
4 ON-crop control	OFF-crop control	ON-crop control	OFF-crop control	0.7bc/0.4b	0.6 b	2.6a/2.8a	2.7 a	0.6d/0.8d	0.7 e
5 NAA-West side of tree	NAA-East side of tree	NAA-West side of tree	NAA-East side of tree	1.1b/ <b>0.9b</b>	1.0 b	<b>2.5a</b> /2.4ab	2.4 a	1.4c/ <b>1.2cd</b>	1.3 cd
6 Pruned-West side of tree	Pruned-East side of tree	Pruned-West side of tree	Pruned-East side of tree	0.6c/ <b>0.9b</b>	0.7 b	<b>2.7a</b> /2.2bc	2.4 a	0.1e/ <b>1.5c</b>	0.8 de
<i>P</i> -value				< 0.0001/ < 0.0001	< 0.0001	< 0.0001/ 0.0002	< 0.0001	< 0.0001/ < 0.0001	<0.0001

<sup>z</sup> All trees were topped on July 7, 2017, May 30, 2018, May 31, 2019 and June 1, 2020.

<sup>y</sup> Mean values within a vertical column followed by different letters are significantly different at the specified *P* level by Fisher's Protected LSD test.

**Table 2.** Effects of crop load and two fruit thinning treatments, foliar application of the PGR NAA at full bloom and pruning after full bloom (June 26, 2017, May 30, 2018, May 31, 2019, and June 2, 2020) to one side of the tree and then the other side annually or every other year on 'Manzanillo' olive tree annual yield in 2017, 2018, 2019 and 2020, 2-year cumulative for 2017+2018, 2018+2019, and 2019+2020.

2017 <sup>z</sup>	2018	2019	2020	2017	2018	2019	2020	Cumulative yield		
Treatment <sup>z</sup>				Yield	Yield	Yield	Yield	2017+2018	2018+2019	2019+2020
				(kg/tree)	(kg/tree)	(kg/tree)	(kg/tree)	(kg/tree)	(kg/tree)	(kg/tree)
1 OFF-crop control	ON-crop Control	OFF-crop control	ON-crop control	25.3 c <sup>y</sup>	121.5 a <sup>x</sup>	134.6 d	79.3 a	146.9 a	256.1 a	213.8 a
2 No treatment	NAA-East side of tree	No treatment	NAA-West side of tree	20.3 c	83.6 b	156.1 bcd	28.5 b	103.8 a	239.7 abc	184.7 b
3 No treatment	Pruned-East side of tree	No treatment	Pruned-West side of tree	15.4 c	100.5 ab	141.6 cd	59.6 a	115.9 a	242.0 abc	201.2 ab
4 ON-crop control	OFF-crop control	ON-crop control	OFF-crop control	103.9 a	26.8 c	211.4 a	9.7 c	130.7 a	238.2 abc	221.1 a
5 NAA-West side of tree	NAA-East side of tree	NAA-West side of tree	NAA-East side of tree	71.3 b	39.6 c	179.8 b	24.2 b	110.9 a	219.3 bc	204.0 ab
6 Pruned-West side of tree	Pruned-East side of tree	Pruned-West side of tree	Pruned-East side of tree	69.3 b	47.5 c	161.4 bc	20.4 b	116.9 a	208.9 c	181.7 b
<i>P</i> -value				< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.1182	0.0724	0.0419

<sup>z</sup> All trees were topped on July 7, 2017, May 30, 2018, May 31, 2019 and June 1, 2020.

<sup>y</sup> Mean values within a vertical column followed by different letters are significantly different at the specified *P* level by Fisher's Protected LSD test.

**Table 3.** Effects of crop load and two fruit thinning treatments, foliar application of the PGR NAA at full bloom and pruning after full bloom (June 26, 2017, May 30, 2018, May 31, 2019, and June 2, 2020) to one side of the tree and then the other side annually or every other year on 'Manzanillo' olive tree on annual total yield and average fruit size.

2017 <sup>z</sup>	2018	2019	2020	2017		2018		2019		2020	
				Yield (kg/tree)	Fruit size (g/fruit)	Yield (kg/tree)	Fruit size (g/fruit)	Yield (kg/tree)	Fruit size (g/fruit)	Yield (kg/tree)	Fruit size (g/fruit)
1 OFF-crop control	ON-crop Control	OFF-crop control	ON-crop control	25.3 c <sup>y</sup>	5.5 a	121.5 a	4.4 d	134.6 d	3.5 a	79.3 a	3.8 c
2 No treatment	NAA-East side of tree	No treatment	NAA-West side of tree	20.3 c	5.6 a	83.6 b	4.9 c	156.1 bcd	3.1 b	28.5 b	4.5 b
3 No treatment	Pruned-East side of tree	No treatment	Pruned-West side of tree	15.4 c	5.5 a	100.5 ab	4.3 d	141.6 cd	3.3 ab	59.6 a	4.0 c
4 ON-crop control	OFF-crop control	ON-crop control	OFF-crop control	103.9 a	4.1 c	26.8 c	6.1 a	211.4 a	2.6 c	9.7 b	4.9 a
5 NAA-West side of tree	NAA-East side of tree	NAA-West side of tree	NAA-East side of tree	71.3 b	4.9 b	39.6 c	5.5 b	179.8 b	3.2 ab	24.2 b	4.7 ab
6 Pruned-West side of tree	Pruned-East side of tree	Pruned-West side of tree	Pruned-East side of tree	69.3 b	4.7 b	47.5 c	5.6 ab	161.4 bc	2.9 bc	20.4 b	4.5 b
<i>P</i> -value				<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

<sup>z</sup> All trees were topped on July 7, 2017, May 30, 2018, May 31, 2019 and June 1, 2020.

<sup>y</sup> Mean values within a vertical column followed by different letters are significantly different at the specified *P* level by Fisher's Protected LSD

**Table 4.** Effects of crop load and two fruit thinning treatments, foliar application of the PGR NAA at full bloom and pruning after full bloom (June 26, 2017, May 30, 2018, May 31, 2019, and June 2, 2020) to one side of the tree and then the other side annually or every other year on 'Manzanillo' olive tree annual yield and fruit size distribution in 2020 and 2-year cumulative yield (2019 + 2020) of medium and large size fruit.

Treatment <sup>z</sup>	2017	2018	2019	2020	Total yield and yield for each fruit size category					2-year cumulative yield		
					Total	Sub-petite	Petite	Small (kg/tree)	Medium	Large	Medium	Large
1 OFF-crop control	ON-crop Control	OFF-crop control	ON-crop control		79.3 a <sup>y</sup>	4.9 a	12.8 a	26.2 a	19.3 a	13.8 a	51.1 a	29.9 a
2 No treatment	NAA-East side of tree	No treatment	NAA-West side of tree		28.5 b	0.3 b	1.8 b	5.5 b	7.5 bc	10.5 a	36.6 abc	17.1 ab
3 No treatment	Pruned-East side of tree	No treatment	Pruned-West side of tree		59.6 a	2.0 b	9.8 a	18.9 a	15.4 ab	12.7 a	51.6 a	20.2 ab
4 ON-crop control	OFF-crop control	ON-crop control	OFF-crop control		9.7 b	0.0 b	0.0 b	0.1 b	0.6 c	6.3 a	16.9 c	9.3 b
5 NAA-West side of tree	NAA-East side of tree	NAA-West side of tree	NAA-East side of tree		24.2 b	0.3 b	2.1 b	3.1 b	7.5 bc	8.7 a	40.8 ab	30.5 a
6 Pruned-West side of tree	Pruned-East side of tree	Pruned-West side of tree	Pruned-East side of tree		20.4 b	0.0 b	0.5 b	3.2 b	5.7 bc	9.7 a	23.9 bc	14.0 b
<i>P</i> -value					< 0.0001	0.0054	0.0024	< 0.0001	0.0221	0.4696	0.0084	0.0364

<sup>z</sup> All trees were topped on July 7, 2017, May 30, 2018, May 31, 2019 and June 1, 2020.

<sup>y</sup> Mean values within a vertical column followed by different letters are significantly different at the specified *P* level by Fisher's Protected LSD test.

## CALIFORNIA OLIVE COMMITTEE

### PROJECT PLAN/RESEARCH GRANT PROPOSAL

Workgroup/Department: School of Engineering – Mechanical Engineering

Project Year: Anticipated Period of Performance: 05/15/2021 – 05/14/2022

**Project Title: Combining trunk shaking and canopy shaking for a highly efficient, low-cost olive harvester – Part 2**

**Project Leaders:** Reza Ehsani (Professor, University of California, Merced, 5200 N. Lake Road, Merced, CA 95343, (209) 228-3613, [rehsani@ucmerced.edu](mailto:rehsani@ucmerced.edu))

**Cooperators:** Louise Ferguson, CE Pomologist, Department of Plant Sciences, UC Davis, Email: [lferguson@ucdavis.edu](mailto:lferguson@ucdavis.edu), Phone: (559) 737-3061

Commodity: \_\_\_\_\_ Relevant AES/CE Project No.:

Year Initiated: 2021\_ Anticipated Duration of Project: one year

#### **Problems and Significance:**

Harvesting is the major cost of production for many crops including olive. Mechanical harvesting of olives was initiated in the US in the 1940s. The main goal was to develop a cost-effective technique to harvest olive fruit for both table and oil extraction (Sola-Guirado et al., 2014). Among all the proposed methods, mechanical shaking has been the most successful approach for fruit removal and machines were commercially available. Different shakers, trunk, branch, and canopy contact, were developed (Jimenez-Jimenez et al., 2015 and Famiani et al., 2014). The efficiency of these shakers was improved with canopy management that limited tree height and formed upright scaffolds. Trunk shakers had lower fruit removal efficiency due to the damping effect of branches (Castro-Garcia et al., 2014 and Ferguson et al., 2014). Besides the lower efficiency, damage to the bark of the trunk and branches causes lowered yield in succeeding years and increased the risk of infestation and disease in the trunks (Jimenez-Jimenez et al., 2015). For other types of shakers, especially canopy shakers, damage to the branches and leaves, and final fruit quality issues such as cuts and flesh injury were a problem (Ferguson et al., 2010). This fruit damage reduced market acceptability, especially of green processed table olives. To solve the issues with mechanical harvesting of traditional orchards, Ferguson et al. (2010) suggested modifying the canopy size and shape of conventional trees and mechanical harvester parameters simultaneously.

Although some olive growers are having some success with trunk shakers, this method has not been widely utilized because the willowy olive trees growth habit prevents the effective transmission of vibrational energy from the trunk to the small distal branches where the fruit is located. To remove fruit with a trunk shaker requires a large amount of energy and extended

duration which can cause tree damage. Also, for some older orchards, the trunk shaker may not be an option due to the size and shape of the trunk and/or canopy.

Engineers at UC Davis developed a prototype canopy contact shaker that was tested with some success and which was very similar to the canopy shaker used to harvest Florida juice oranges. Ehsani’s group at UC Merced used an alternative design to develop a 50% lighter canopy contact shaker-based fruit removal system that can accommodate larger trees. This system has shown promising results as well. The UC Merced design was able to produce the maximum shaking energy at the fruit level as opposed to the trunk, and hence, less damage to the tree. However, it

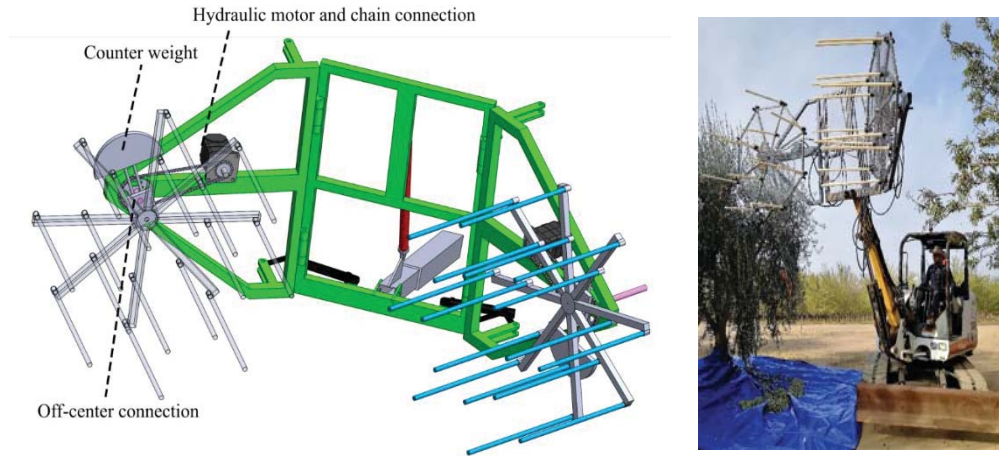


Figure 1. UC Merced fruit removal canopy shaking head

took a longer time to shake each tree.

In part one of this COC funded project a simultaneous combination of trunk and canopy shaker technologies were tested in 2020. The combined shaking methods demonstrated a higher harvest efficiency compared to using either alone.

In the 2021 project, we propose to build a new prototype harvester combining both trunk and canopy shaker in one machine. We intend to conduct extensive field tests to assess the best shaking parameters, amplitudes and frequencies. These parameters are needed for fine tuning the machine to achieve the optimal machine capacity.

**Progress to Date:**

This project is the continuation of a previously funded California Olive Committee project.

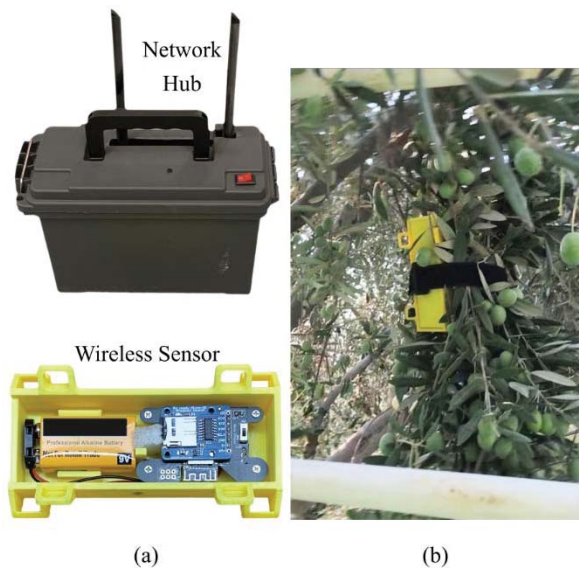


Figure 2. Wireless sensor module and network hub (a) and a wireless sensor module installed on olive branches for data collection (b).

Merced. Figure 1 shows the UC Merced canopy shaker fruit removal system.

The UC Merced-designed canopy shaker was tested in 2018, 2019 and 2020.. To measure and record vibration distribution throughout the canopy, we developed a wireless sensor system consisting of a network hub unit and multiple wireless sensing modules. Each sensing module has a built-in 3D accelerometer, wireless module, storage module and a battery. These sensors can record data up to 550 samples per second in each axis. The network hub unit connects wirelessly to all the sensing modules and triggers the data collection procedure (Figure 2).

### UC Merced canopy shaker

Figure 1 shows the UC Merced canopy shaker fruit removal system developed in Ehsani’s lab. This canopy shaker was tested in 2018 and 2019. To measure and record vibration and force distribution throughout the canopy, a wireless sensor system consisting of a network hub and multiple sensing modules was developed. Each sensing module has a built-in 3D accelerometer, wireless module, battery, and storage unit. The network hub connects wirelessly to all the sensing modules and lets the operator trigger data recording via a smartphone app (Figure 2) Three accelerometer sensors were attached to a tree to monitor tree vibration. One sensor was attached to the tree trunk, one to the main branch, and one to a second smaller branch. Using these sensors, the we could compare the acceleration distribution throughout the tree canopy of both the UC Merced’s canopy shaker and a trunk shaker harvester. Figure 3 shows the acceleration of each sensor for each of these harvesters when both were shaking a tree simultaneously. The data collected from the canopy shaker (Figure 3) shows that the small-diameter branches vibrate at a higher acceleration than the larger primary branches and trunk. The canopy shaker transmitted

more energy to the small branches than to the tree trunk and root system (Figure 4B), potentially producing less tree damage than a trunk shaker. Figure 4A shows the data collected for the trunk shaker. It shows there is much higher acceleration in the trunk than the small branches, indicating the UC Merced canopy shaker applies most of the energy where the fruits are located, and therefore is more efficient. Compared to trunk shaking, the amount of acceleration (force) decreased by 70% at the tree trunk and 57% at the main branches and increased by 134% at the small branches. Figure 4C shows



Figure 3. Root mean square of vibration measured at each part of a tree (left) and maximum acceleration produced by the two harvesters at each part of a tree (right).

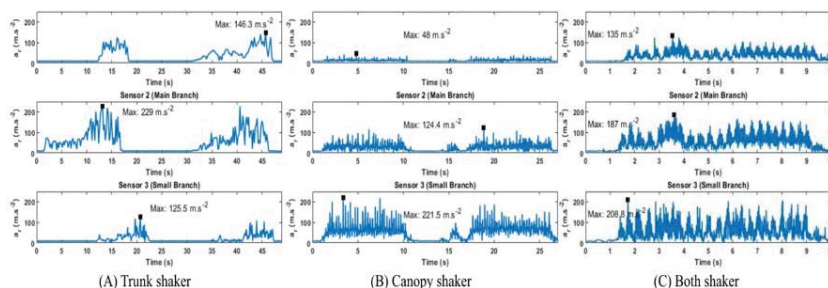


Figure 4. Vibration transmission through tree using (A) trunk shaker, (B) Ehsani’s lab canopy shaker and (C) both shaker working at the same time.

the results of the test in which a tree was shaken using both the canopy shaker and trunk shaker at the same time. Figure 3 shows the root mean square and maximum amplitude of vibration recorded by the sensors on the tree. This figure demonstrates that a combination method of shaking (both trunk and canopy) would more effectively remove fruit in less time. It shows a more uniform distribution of energy throughout the canopy.

**Combined shaker experiment**

A combination trunk shaker and UC Merced canopy shaker was tested on 33 trees during the 2020 harvest season in Nickels Soils Laboratory orchard Arbutle, CA). An Orchard Machinery Corporation (OMC) the trunk shaker was used. For each shaker, trunk and canopy, three different shaking frequencies was chosen. Eleven trials were conducted including the nine combinations of shaking frequencies (Figure 5), and one trial each using the trunk shaker and UC Merced canopy shakers alone (Table 1). Each trial had three replicates (a total of 33 trees). The canopy shaker was set to a 2" off-center distance, generating an oscillation with a 4" amplitude. Rotational speed was set to 100, 150 and 200 rpm for the experiment. The trunk shaker intensity was set to low, medium and high. Shake duration was set to 15 seconds.



Figure 5 Trunk shaker and canopy shaker, shaking an olive tree simultaneously

Table 1. Experiment design for selecting the optimum combined shaking frequency. Each treatment will be replicated three times.

Trunk shaker intensity \ Canopy shaker (rpm)	Low	Medium	High
100	Trial-1	Trial-2	Trial-3
150	Trial-4	Trial-5	Trial-6
200	Trial-7	Trial-8	Trial-9
Canopy shaker		Trial-10	
Trunk shaker		Trial-11	

Tarps were used to collect the mechanically harvested fruit for weighing. An experienced olive harvesting gleaning crew was hired to harvest the fruit remaining on the trees. The manually harvested fruit was weighed and recorded. Harvest efficiency was calculated using equation below.

$$\text{Efficiency} = \frac{\text{Mechanically harvested (lb)}}{\text{Manually harvested (lb)} + \text{Mechanically harvested (lb)}} \times 100$$

Harvest efficiency for each of 11 trials is shown in Figure 6. Trial 1 through trial 9 used the UC the Merced canopy and the OMC trunk shakers simultaneously. Trial 10 used the UCM canopy shaker alone and trial 11 used the OMC trunk shaker alone.

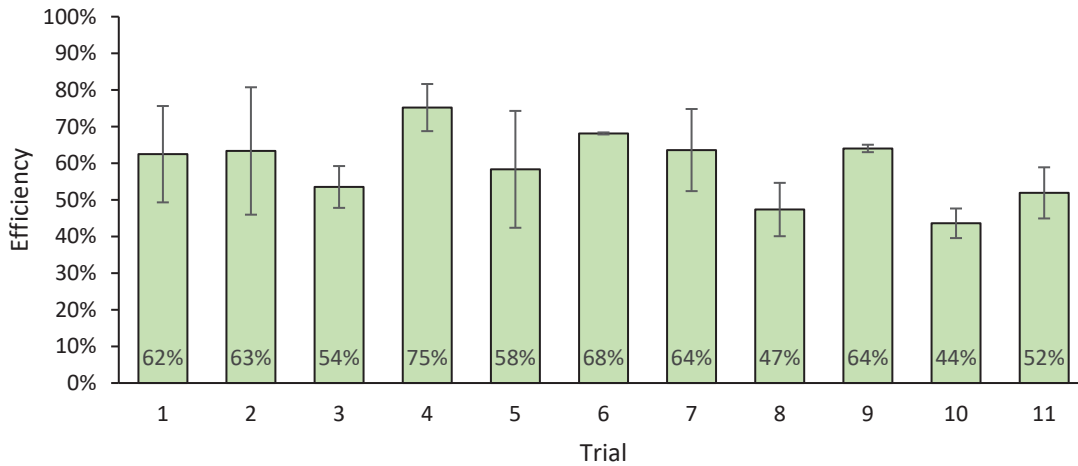


Figure 6 Harvest efficiency for all trials. Trials 1 to 9 were used both canopy shaker and trunk shaker simultaneously, Trial 10 has used UC Merced canopy shaker only and trial 11 has used the OMC trunk shaker.

Figure 6 shows using both shakers simultaneously, except for trial 8, produced better harvest efficiencies compared to using shaker individually. Figure 7 shows the average harvest efficiency of all three shaking methods. This figure shows the combined shaker method has improved harvest efficiency by 41% and 19% compared to canopy shaker and trunk shaker alone, respectively.

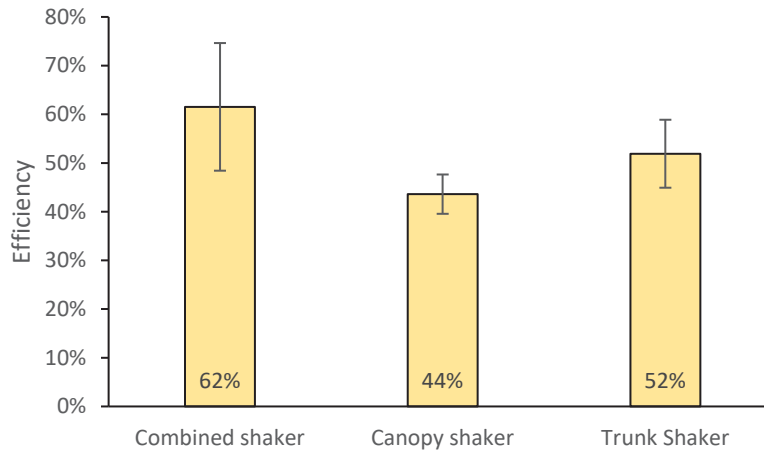


Figure 7 Comparing harvest efficiency of all three methods.



*Figure 8. Proposed shaker design that includes both canopy shaker and trunk shaker components.*

These results demonstrate harvesting an olive tree using trunk and canopy contact shakers simultaneously will increase harvest efficiency. Among the nine trials using both shakers, trials 4 and 6 had the highest harvest efficiencies, 75% and 68% respectively. Vibration data and lab quality results will be presented in the final report. A modified canopy shaker design was discussed and conceptualized based on field observation and will also be proposed.

### **Objectives:**

The goal of this study is to increase the profitability of table olive by reducing harvesting costs using mechanical harvesting machines. The specific objectives are as follows:

- **Objective 1:** Design and build a combined trunk and canopy shaker machine specifically for table olives based on the tree and fruit properties.
- **Objective 2:** Study the effect of pruning on harvest efficiency.
- **Objective 3:** To disseminate the integrated knowledge gained through this research.

### **Experimental Procedures:**

To achieve the objectives, the following tasks are planned:

**Task 1:** Design a combined shaker machine for table olive harvesting

**Task 2:** Build the designed combined shaker

**Task 3:** Evaluate the performance of the machine in the field

**Task 4:** Study whether pruning would increase harvest efficiency or not.

**Task 5:** Write the final report and publish the results.

The proposed trunk shaker includes both canopy and trunk shaking components (Figure 8). It will be pulled by a tractor in the field and be powered by the tractor's hydraulic source. Two of these machines will be built; both will have a canopy shaking component but only one will have the trunk shaking component. The two shakers will compress and harvest a tree from the opposite sides simultaneously with the trunk shaker from one side only.

**Field Trial procedure:**

The proposed shakers will be tested in Nickels Soils Laboratory olive orchard (Arbuckle, CA) during harvest 2021. Two shaking frequencies for the canopy shaking component and trunk shaking component will be tested and evaluated. Each trial will be tested on three trees (Table 2).

*Table 2. Experiment design for selecting the optimum combined shaking frequency. Each treatment will be replicated three times*

Trunk shaker Canopy shaker	Freq.1	Freq.2
Freq.1	Trial-1	Trial-2
Freq.2	Trial-3	Trial-4

The best frequency combination will be chosen and tested in a second field test to identify the effect of pruning on harvest efficiency (Table 3). These trials will be replicated five times.

In a separately submitted coordinated experiment the 4 frequency combination above will repeated on 3 trees receiving an ethephon spray.

*Table 3. Experiment design for evaluating effect of pruning on harvest efficiency.*

Unpruned Olive trees	Trial-5
Pruned Olive trees	Trial-6

**Project Timeline:**

Tasks	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
Task 1												
Task 2												
Task 3												
Task 4												
Task 5												
Task 6												

**BUDGET REQUEST: Reza Ehsani**

Budget Year: 2021

Funding Source: COC

<b>Labor:</b>	<b>Line 1</b>
Salary	
One Graduate Student Researcher	
Full-Time during Academic Terms and 50% during Summer Term	\$29,373
1.3% Benefit Rate	\$382
<b>Subtotal 1</b>	<b>Line 1 Subtotal \$29,755</b>
<b>Supplies:</b>	<b>Line 2</b>
Supplies: Estimates for hauling the mechanical harvester to the field (\$3,000), raw materials for fabrication, hydraulic components, hosing and hydraulic motors, hydraulic valves (\$12,000), consumable shop and welding supplies, supplies for field data collection supplies (\$1,750)	
<b>Subtotal 2</b>	<b>Line 2 subtotal \$16,750</b>
<b>Travel:</b>	<b>Line 3</b>
Vehicle Use: Truck use for two weeks for field trials (\$190.00/week)	\$0
For work site and COC meetings	\$0
Dr. Ferguson travel charges, for work site and COC meetings	\$0
<b>Subtotal 3</b>	<b>Line 3 subtotal \$0.00</b>
<b>Tuition/Fees:</b>	<b>Line 4</b>
Graduate student fees and tuition for the 9-month academic year for a non-resident graduate student. University policy requires the inclusion of tuition/fee remission for graduate student researchers employed 25% time or more during the academic year. These costs are based on published University rates with a 10% increase.	
	\$15,793
<b>Subtotal 4</b>	<b>Line 4 subtotal \$15,793</b>
<b>Total of lines 1 through 4 above</b>	<b>(Line 5) \$62,297</b>
<b>Modified Total Direct Cost</b>	<b>(Line 6) \$62,297</b>
<b>UCD/ANR/UCR Overhead @ 11% IDC on MTDC (Line 6)</b>	<b>(Line 7) \$7,700</b>
<b>Total to Primary PI)</b>	<b>(Line 5 + 7) \$69,997</b>
<b>TOTAL BUDGET REQUEST</b>	<b>\$69,997</b>

**PRIMARY PI SIGNATURE PAGE: UNIVERSITY OF CALIFORNIA**

*Reza J Ehsani*

\_\_\_\_\_  
Originator's Signature

\_\_\_\_10/30/2020\_\_\_\_  
Date

**Jue C. Sun** Digitally signed by Jue C. Sun  
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Director Sponsor Project Office

\_\_\_\_\_  
Date

\_\_\_\_\_  
Contracts and Grants Officer

\_\_\_\_\_  
Date

Institution/Organization: University California, Davis

Department/Division: Plant Sciences

Project Year: 2020- 2021

Anticipated Duration of Project (yrs.): 4+

Principal Investigator:

Giulia Marino, Cooperative Extension Specialist in Orchard Systems, University of California Davis, [giumarino@ucdavis.edu](mailto:giumarino@ucdavis.edu) (559) 646-6585

Co-PIs and Collaborators

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Richard Rosecrance, professor of fruit tree physiology and plant mineral nutrition, Chico State Univesrity, College of Agriculture, [rosecrance@csuchico.edu](mailto:rosecrance@csuchico.edu)

Project Title: Precise water management strategies for table olive orchards in California

### Abstract

Modern, high-density olive acreage has rapidly increased in California (CA) within the last two decades, but estimating olive water needs is based on a crude, 31-year-old method for low-density orchards that were

flood irrigated. Precise, grower friendly deficit irrigation management is crucial for the economical and environmental sustainability of this industry.

We propose a multidisciplinary approach for developing deficit irrigation strategies for CA olive systems that will: 1) focus on specific phenological stages, 2) be based on actual water use and water status information, 3) be easy to implement and 4) increase the competitiveness of CA olive industry by increasing water use efficiency.

The project will benefit olive producers, farm managers, irrigation consultants, and water resource managers by helping them maximize yields and quality with highly efficient irrigation as the industry faces supplies now constrained by climate change and state groundwater management policies.

#### Problem and significance:

Precise management of irrigation (timing and water amount) is crucial for matching the optimal water use and the economical sustainability of olive systems. For this reason, a big research effort has been carried out in the last 30 years to develop clear guidelines to manage correctly water in olive orchards. As a result, it is commonly accepted that to maximize orchard performance, and net income, irrigation should be applied in accordance with orchard water requirements during tree and fruit water sensitive periods. When it comes to deficit irrigation strategies, controlled water stress should be applied at specific tree and fruit developmental periods less sensitive to irrigation water shortages. In particular, water stress during pit hardening reduces vegetative growth rather than fruit growth, resulting in a desired control of canopy growth (Rosecrance et al 2016), higher fruit quality (Cano-Lamadrid et al 2015) and higher accumulation of cuticular waxes that protect olives from bruises associated with mechanical harvesting (Casanova et al 2017, 2019). Unfortunately, most of these guidelines have been developed in Spain, and therefore California olive oil growers still lack some essential local research information to apply water efficiently. CA olive irrigation research is based on a crude crop coefficient developed in 1989 for flood-irrigated, widely spaced orchards that does not (1) reflect industry shifts to high-density orchards, (2) recognize crop water-need variability that occurs throughout the season, (3) reflect a temperature-based model to characterize water-sensitive phenological stages and (4) include protocols to apply controlled deficit irrigation.

#### Objectives:

We propose a multidisciplinary approach to address these data gaps, by combining experts in biometeorological measurements, plant physiology, fruit physiology, water management, orchard management, food science and remote sensing to develop improved irrigation strategies to maximize table olive orchard performance under optimal water use, for enhanced fruit quality and therefore, increased net income.

In particular, we aim to:

1. Develop updated water use information (ET and Kc) for a mature, well-irrigated, high-yielding, table olive orchard with drip-irrigation and typical California production practices.
2. Develop deficit irrigation protocols for table olive growers in California to reduce water during stress tolerant periods without affecting yield but improving fruit quality, water productivity and light distribution within the canopy.
3. Develop preliminary environmental, plant-based and remote sensing information to move toward the automatization of precise and efficient water management in olive
4. Conduct an extension educational and outreach activities for olive producers and other stakeholders in California

### Plans and procedures:

One orchard has been identified in a major olive production region (Corning). The 30-years old orchard, planted at 180 tree/ha and mechanically harvested is representative of the CA table olive industry.

The study orchard will be instrumented in winter of 2021, before the beginning of the production season, with micro-meteorological sensors (surface renewal/eddy covariance) to directly measure real time orchard actual crop evapotranspiration (ET<sub>a</sub>). In addition, flow meters and soil moisture sensors will be installed to monitor water applications and soil moisture. The irrigation system will be modified to apply the following irrigation treatments:

- 1- Control, grower normal irrigation practices (K<sub>c</sub> used by the grower)
- 2- ET<sub>olive</sub>, actual ET as determined by eddy covariance/surface renewal station
- 3- RD11: Regulated deficit irrigation during pit hardening (50% of ET<sub>a</sub>)
- 4- RD12: Regulated deficit irrigation during pit hardening (75% of ET<sub>a</sub>)

The experiment will be laid out in a randomized block design with four blocks, each consisting of 12 adjacent rows (4 subplots of three adjacent rows per irrigation treatment). The central rows from each irrigation sub-plot will be used for data collection.

Data on ET will be collected continuously. In addition, 10 fruits will be harvested weekly and brought to the lab where the following measurements will be taken: fresh weight and dry weight, pit-breaking pressure, color, pit to stone ratio and cuticular wax content. Data collected will be used to develop a phenological model to predict fruit growth stages as a function of temperature and tree physiology.

The following parameters that will be also measured during the experimental trial:

- Midday stem water potential: once every two weeks during the whole reproductive season and once per week during the deficit irrigation period, to characterize the deficit irrigation as bars below baseline
- Stomatal conductance and net photosynthesis: once per month during the whole reproductive season and once every two weeks during the deficit irrigation period in the first two years, to characterize the impact of water stress on gas exchanges
- Canopy reflectance in the visible, near infrared, and shortwave infrared regions through remotely-sensed imagery
- Leaf area index and light penetration within the canopy: three times a year (before deficit onset, after deficit onset and after harvest) for 4 years, to characterize the impact of deficit irrigation on reducing vegetative growth
- Distribution of reproductive growth within the canopy will be characterized once a year before harvest to evaluate the impact of better light penetration within canopy on fruiting patterns
- Fruit yield quantity and quality will be measured annually at harvest.
- Harvest efficiency, fruit bruising and amount of cuticular waxes

### Expected outcomes:

The information developed within this project will have a potential to increase the competitiveness of California olive industry through better irrigation management practices resulting in increased orchard yield

and quality, reduced vegetative versus reproductive growth, increase water and energy productivity, reduced inputs, increased efficiency, and increased economic income. The project outcomes will be primarily beneficial for the California growers to inform decisions related to water resource planning, allocation, management and transfer as the water supply uncertainties are increasing through drought risks and environmental regulations.

Casanova, L., Corell, M., Suárez, M. P., Rallo, P., Martín-Palomo, M. J., Morales-Sillero, A., ... & Jiménez, M. R. (2019). Bruising response in ‘Manzanilla de Sevilla’ olives to RDI strategies based on water potential. *Agricultural Water Management*, 222, 265-273.

Casanova, L., Corell, M., Suárez, M. P., Rallo, P., Martín-Palomo, M. J., & Jiménez, M. R. (2017). Bruising susceptibility of Manzanilla de Sevilla table olive cultivar under Regulated Deficit Irrigation. *Agricultural Water Management*, 189, 1-4.

Cano-Lamadrid, M., Girón, I. F., Pleite, R., Burló, F., Corell, M., Moriana, A., & Carbonell-Barrachina, A. A. (2015). Quality attributes of table olives as affected by regulated deficit irrigation. *LWT-Food Science and Technology*, 62(1), 19-26.

Rosecrance, R. C., Krueger, W. H., Milliron, L., Bloese, J., Garcia, C., & Mori, B. (2015). Moderate regulated deficit irrigation can increase olive oil yields and decrease tree growth in super high density ‘Arbequina’ olive orchards. *Scientia Horticulturae*, 190, 75-82.

## RESEARCH GRANT PROPOSAL BUDGET WORKSHEET

Contract administrator: Thomas Luong

Email: tomluong@ucdavis.edu

Telephone:

ITEM	2020-21	2021-22	2022-23	2023-24
Salaries	\$20,145	\$7,468	\$7,692	\$7,923
Employee benefits	\$7,977	\$159	\$163	\$169
Employee benefits	\$7,977	\$159	\$163	\$169
Supplies (parts ET station, irrigation system modification, soil moisture sensors)	\$16,000	\$3,000	\$3,000	\$3,000
Travel	\$1,600	\$1,600	\$1,600	\$1,600
Miscellaneous (lab material for phenological characterization)	\$3,200	\$3,200	\$3,200	\$3,200

Total (without overhead)	\$48,922	\$15,427	\$15,655	\$15,891
Total with overhead (with 11% overhead)	\$54,303.42	\$17,123.97	\$17,377.05	\$17,639.01

Originator's signature (PI):



Date: 10/29/2020

Authorized signature:

Date:

University of California  
Division of Agricultural Sciences  
**PROJECT PLAN/RESEARCH GRANT PROPOSAL**

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Project Year: 2021 Anticipated Duration of Project: 1<sup>st</sup> of 3 years

Principal Investigators: J. E. Adaskaveg

Cooperating: D. Thompson and H. Förster

Project Title: Epidemiology and management of olive knot caused by *Pseudomonas savastanoi* pv. *savastanoi*

Keywords: Bactericides, copper enhancing compounds, antimicrobial natural products, biological controls

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### JUSTIFICATION/ BACKGROUND

*Pseudomonas savastanoi* pv. *savastanoi* (*Psv*), the causal agent of olive knot, is a serious disease of olives (*Olea europaea*) throughout all growing regions of the world (8). The pathogen enters through wounds causing outgrowths (knots, tumors, galls) predominantly on trunks, branches and twigs. Olive knot is the most economically important disease of olives. Infection may lead to tree defoliation, dieback, and reduced vigor, which ultimately lowers fruit yield and quality (6), and the disease may lead to orchard failure. *Psv* can survive epiphytically on olives, but the main source of inoculum is bacteria living within knots (7). Large quantities of bacterial ooze can be exuded when knots become wet (12). This exudate is disseminated by rain, wind, insects, birds, as well as human activity. The opportunistic pathogen invades wounds caused by natural leaf abscission (4), frost, and hail, as well as cultural practices such as pruning and harvesting. Sodium hypochlorite or quaternary ammonia that was recently registered under a special local need (Section 24c) registration based on efforts from this project can be used to sanitize field equipment and minimize the spread of the pathogen during harvest and pruning operations (10). After entering its woody host, the pathogen induces knot formation through the production of indoleacetic acid (IAA) and cytokinins (2). In California, infections occur mostly during the rainy season (late fall, winter, and spring) but knots do not develop until new growth starts in the spring. Infections can occur at low temperatures (-5°C) and thus, wetness is the main limiting factor for the disease. None of the currently grown olive cultivars is resistant to the pathogen (5).

Control of olive knot is difficult, and growers rely on applications of copper-based bactericides as the only effective foliar treatment. Manual application of cresol- and xylenol-based compounds (Gallex) to individual knots can eliminate the pathogen but is unfeasible on a commercial scale due to phytotoxicity when applied as an air-blast foliar treatment. Copper has been extensively used in olive production for many years for the control of peacock spot and olive knot. Reliance on a single active ingredient has led to our detection of copper resistance in *Psv* strains from some commercial olive orchards. Still, the incidence of copper resistance is currently very low, accounting for only 2% of the total strains collected in a survey of olive growing regions of California. When resistant strains were inoculated to Arbequina and Manzanillo olive wounds, application of copper provided reduced or no control as compared to inoculation with a sensitive strain. Therefore, there is a potential risk of copper resistance spreading with the continued and sole use of copper. This necessitates the development of new bactericides or copper-activity-enhancing materials to overcome resistance. The latter strategy has proven to be effective for walnut blight management where copper resistance in *Xanthomonas arboricola* pv. *juglandis* is common, and copper-mancozeb mixtures have provided exceptional control for many years. Mancozeb can no longer be registered on new crops, but other alternatives need to be evaluated.

We have been instrumental in the development of the new agricultural antibiotic kasugamycin (Kasumin) for several bacterial diseases of agronomic crops in the United States. Kasugamycin has high activity against *Erwinia* (1) and *Pseudomonas* (11) and moderate activity against *Xanthomonas* species and other plant pathogenic bacteria. Over several years of studies, we found it to be the most effective new treatment for preventing olive knot (11). Kasugamycin was highly effective in controlling olive knot on naturally formed leaf scars and wounds created by hedging or harvesting. Kasugamycin was first federally registered on pome fruits, followed by registrations on cherry and walnut. Registration on peaches and almonds is pending for late 2021. The olive submission of kasugamycin to the EPA was late summer of 2020

because new residue trials and laboratory analyses were needed and were completed in 2019. Kasugamycin would greatly complement current copper sprays and could be used in rotation or mixtures with copper. Oxytetracycline is also pursued for registration through the IR-4 program. It was also submitted in late summer 2020, and registrations of both are expected to be simultaneous. We plan to conduct additional studies with oxytetracycline and kasugamycin to potentially improve use of these antibiotics by adding reduced rates of copper or food-grade antimicrobials (exempt from tolerance) to protect wounds until they heal. The fungicide dodine has been reported to have bactericidal properties when used at high labeled rates. Since this compound is being registered for peacock spot, we plan to evaluate it as a bactericide alone or in combination with other antimicrobials (i.e., copper, antibiotics, and food-grade antimicrobials).

Another strategy is the use of natural products. We evaluated several of these over the last two years with inconsistent but high success in some trials. We attributed this to using unformulated active ingredients that do not have adjuvants to stabilize and prevent degradation. These promising new treatments are antibacterial food preservatives that are FDA ‘generally recognized as safe’ (GRAS) products. They are naturally produced by gram-positive *Streptomyces* species. Integration of these alternative materials with conventional copper or newly registered antibiotic treatments may provide consistent high disease control, reduce the risk of resistance development, and provide olive growers with more resources for managing olive knot. In 2018 to 2020, we evaluated the GRAS compounds nisin,  $\epsilon$ -poly-L-lysine, and organic acids including the commercial product Dart containing capric/caprylic acids in field trials by themselves and in selected mixtures with other compounds. In 2020, disease control was comparable to that of copper or kasugamycin treatments using high rates of  $\epsilon$ -poly-L-lysine mixed with Dart or with nisin and lactic acid. These are exciting results, and UPL is working with us to develop agricultural formulations of nisin and  $\epsilon$ -poly-L-lysine that may be more stable in the environment. This registrant will support EPA biopesticide registrations and is also supporting the dodine (as well as the polyoxin-D) registrations on olive.

Therefore, we showed that field performance of new treatments can be improved, and we are working to formulate nisin and  $\epsilon$ -poly-L-lysine as part of an ongoing process to develop new GRAS bactericides for olive knot control. Potential strategies for optimizing these compounds include reformulation with acids and the addition of adjuvants (9) to prevent photo- or UV-degradation, and the use of these materials in mixed treatments with other products (e.g., kasugamycin, dodine). This information is very valuable because rotational programs could be developed with different modes of action for different phases of the disease, i.e., leaf scars during leaf drop or twig wounds occurring during harvest and pruning. These materials are registerable as conventional biopesticides and possibly as organic treatments.

## RESEARCH OBJECTIVES

- 1) **Evaluate new bactericides: GRAS food additives, sanitizers, and other experimentals against *Psv***
  - a) Laboratory in-vitro sensitivity studies: nisin,  $\epsilon$ -poly-L-lysine, mixed with the sanitizers lactic acid or capric/caprylic acids (Dart) alone or combination and in mixtures with selected adjuvants (to improve field stability), as well as dodine as a bactericide (since it is being registered as a fungicide on olive).
  - b) Field efficacy studies with new bactericides in comparison with kasugamycin for the management of olive knot caused by copper-sensitive and -resistant strains of *Psv*.
    - i) Oxytetracycline and kasugamycin formulations in combination with selected adjuvants (e.g., Dart) or low rates of copper in traditional (e.g., Kocide, Champ) and new formulations (e.g., Cueva) with inherent low copper concentrations as compared to traditional products.
    - ii) Nisin,  $\epsilon$ -poly-L-lysine, Dart, and dodine alone, in combination with each other, or in mixtures with antimicrobial acids (e.g., lactic, citric, and capric/caprylic).
- 3) **Continue to support the registration of the antibiotics kasugamycin and oxytetracycline**
  - a) Support letters for both antibiotics from myself and the industry (COC) were provided in the fall of 2020 to IR-4 for inclusion to the IR-4/registrant (UPL for kasugamycin and AgroSource for oxytetracycline) submission petition to EPA.
  - b) Optimizing the efficacy of oxytetracycline, kasugamycin, and dodine under field conditions as they go through the final registration process on olives to ensure guidelines can be provided to the industry for optimal performance.

## PLANS AND PROCEDURES

### 1) Evaluate new bactericides, food additives, GRAS sanitizers, and other experimentals against *Psv*.

a. To evaluate the in vitro toxicity of new formulations of nisin and  $\epsilon$ -poly-L-lysine (provided by UPL), as well as the GRAS organic lactic, citric, and capric/caprylic (Dart) acids alone or combination with each other and selected adjuvants. The spiral gradient endpoint (SGE) or direct contact methods will be used. Hereby bacterial strains are exposed to a bactericide concentration gradient on a single agar plate or in a solution with a single concentration for selected exposure times, respectively. This will allow the determination of minimal inhibitory values for *Psv* of products being evaluated that will help to calculate appropriate field rates.

b. Field studies will be done on Arbequina and Manzanillo olives in established orchards at UC Davis and UC Riverside. Treatments will include oxytetracycline formulations in combination with selected adjuvants to increase persistence, Nisin,  $\epsilon$ -poly-L-lysine, and Dart either by themselves, in combinations, or in mixtures with antimicrobial acids (e.g., lactic, citric, capric/caprylic). Adjuvants will also be continued to be evaluated to determine if the field efficacy can be optimized. Treatments will be compared to Kasumin and copper. Plants will be wounded and then treated. Lateral wounds on 1-2-year-old twigs will be made using a scalpel by removing the bark and exposing cambial tissue. Leaf scars will be made by pulling leaves off the same twigs. In addition, wounds from natural leaf drop will be used. Treatments will be sprayed onto wounds, allowed to air-dry, and inoculations will be done with a suspension of copper-sensitive or -resistant *Psv* strains. The efficacy of treatments will be assessed as the percent incidence of knots forming on treated, inoculated wounds as compared to wounds that are treated with water and inoculated (i.e., controls).

2) Continue to support the registration of the antibiotics kasugamycin and oxytetracycline. An inter-commodity and industry group will continue to work with the Minor Crop Farmer Alliance to recommend an EPA policy change towards the use of antibiotics in plant agriculture. Specifically, a new internal EPA Guidance Document (GD) for use of antibiotics in plant agriculture needs to be developed based on science. Historically, EPA GD 152 for registration of antibiotics in animal husbandry is used for all requests in agriculture. Additionally, we will continue to work with a USDA working group to address CODEX initiatives for establishing policies on all antibiotic use in agriculture including animal and plant uses.

### Benefits to the industry

For management of olive knot, in addition to cultural methods, sanitation practices, and the labor-intensive Gallex, only copper materials and the natural product Regalia are currently available. We obtained improved performance of copper when applications were made within 24 h of wounding events (e.g., harvesting, pruning, hail storms, freezing) as compared to later applications, and we demonstrated that high labeled rates of copper often outperform low rates. In our previous research, we showed that copper resistance is currently only found locally where copper has been used for many years. Because copper-resistant strains of *Psv* were found to be virulent and competitive, and because they were not genetically clonal, there is a risk of further development and spread of copper resistance. Therefore, alternatives are needed for a sustainable and effective management program for many years ahead. We initiated the registration of the new agricultural antibiotic kasugamycin that was registered in 2014 on pome fruits, and in 2018 cherry and walnuts in California. The olive registration is pending in late 2021 after almonds and peaches. Oxytetracycline for use on olive went through the IR-4 program, has been submitted to the EPA in 2020, and registration is pending. Kasugamycin showed high activity against olive knot especially in mixtures with copper. Oxytetracycline also showed consistent high activity in mixtures with low rates of copper. We will continue to explore and evaluate other potential bactericide products that include the natural GRAS products nisin and  $\epsilon$ -poly-L-lysine in mixtures with the sanitizers lactic and capric/caprylic acids. These products are being commercially formulated in cooperation with UPL, who is also the registrant of dodine and kasugamycin. The registration of several materials for olive knot management will allow the implementation of anti-resistance strategies and will prevent over-use of any single mode-of-action bactericide. Still, integrated practices will be critical for the successful management of the disease. Any bactericide treatment will be most effective when pathogen population levels are at a minimum and the host is less susceptible.

**References**

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12. Nguyen, K. A., Förster, H., Adaskaveg, J.E. 2018. Genetic diversity of *Pseudomonas savastanoi* pv. *savastanoi* in California and characterization of epidemiological factors for olive knot development. *Plant Disease* 102:1718-1724.

**Budget Request:**

Funding Source: California Olive Commission and California Olive Oil Commission

**Budget Request with UC indirect costs:**

Budget Year: 2021 Funding Source*:	OOC	COC	Total Budget
Salaries and Benefits: SRA/Postdoc	6,000	6,000	12,000
Lab/Field Ass't	1,000	1,000	2,000
Subtotal	7,000	7,000	14,000
Employees' Benefits**	4,000	4,000	8,000
Subtotal	12,000	12,000	24,000
Supplies and Expenses	0	0	0
University Land and Orchard charges	1,500	1,500	3,000
Operating Expenses/Equipment Travel	0	0	0
Travel	1,500	1,500	3,000
<b>Direct Cost Totals</b>	<b>\$15,000</b>	<b>\$15,000</b>	<b>\$30,000</b>
Off Campus IDC @ 11%		1,650	1,650
<b>Total Budget Requested</b>	<b>\$15,000</b>	<b>\$16,650</b>	<b>\$31,650</b>

*J.E. Adaskaveg*

Date: Oct. 28, 2020

Originator's Signature (PI)

*Katherine Borbook*

Dept. Chair  
(Riverside Campus)

Date: Oct. 28, 2020

Liaison Officer

Date: \_\_\_\_\_



were approved for residue trials at the IR-4 National Food Use Workshop for registration on olives. Strong support was provided for all fungicides based on the after-harvest and winter season usage with expected zero to limit-of-detection residues on the crop in the following harvest season. Ziram, Inspire Super, Quadris Top, and Syllit represent FRAC codes M3, 3/9, 3/11, and U12, respectively. Thus, integration of multi-site MOA with single-site MOA products is planned to establish an effective anti-resistance strategy. Residue trials were conducted in 2019/20, and laboratory analyses will take place in 2021 for the first two fungicides. Research on these and newly identified fungicides needs to continue to provide efficacy of several years and to develop use strategies (i.e., timing, adjuvants).



Fig. 2. Range of symptoms of Peacock spot caused by *Fusicladium oleagineum*.

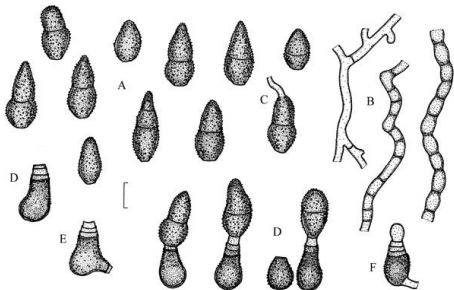


Fig. 2. *Fusicladium oleagineum*. A - conidia, B - superficial septate hyphae, C - germinating conidium, D - conidiogenous cells with several conspicuous annellations, E - percurrent proliferating conidiogenous cell, F - conidiogenous cell arising from a hypha. Scale = 10  $\mu$ m.

## OBJECTIVES

1. Evaluate the performance of new and older fungicides in field trials.
  - a) Multisite MOA fungicides - Dithiocarbamates (ziram) (FRAC Code – M3)
  - b) Single-site MOA fungicides – DMIs (e.g., difenoconazole) pre-mixed with other fungicides like cyprodinil (Inspire Super - FC 3/9) and azoxystrobin (Quadris Top - FC 3/11), polyoxins (Ph-D - FC 19), or guanidines (Syllit - FC U12).
2. Evaluate application timing and adjuvants of selected treatments.
  - a) Timing: Fall, Spring, or Fall and Spring.
  - b) Adjuvants: NuFilm-17 or oil (to increase persistence or activity over the fall/winter season)
3. Evaluate new fungicides for their in vitro activity.
  - a) Determine the in vitro activity of selected fungicides that are effective in field trials.

## PLANS AND PROCEDURES

**1. a,b. Evaluate the performance of new and older fungicides in field trials.** In studies in commercial olive orchards where the disease is known to occur and in an experimental orchard at UC Davis, fungicides including ziram (Ziram - FC M3), chlorothalonil (Bravo - FC M5), difenoconazole (Inspire - FC 3), polyoxin-D (FC 19), and dodine (Syllit FC U12) or mixtures such as difenoconazole/cyprodinil (Inspire Super - FC 3/9) and difenoconazole/ azoxystrobin (Quadris Top - FC 3/11) dodine+polyoxin D (FC U12+19) will be applied using an air-blast sprayer. There will be four replications for each treatment in a randomized complete block design. Disease incidence and severity will be evaluated in late spring. Data will be analyzed statistically using ANOVA procedures and mean separation procedures of SAS 9.4.

**2. Evaluate application timing and adjuvants of selected treatments.** In field studies, selected fungicides will be applied at different timings to compare fall vs. spring or fall + spring timings. Additionally, capric/caprylic acids to improve pesticide performance will also be evaluated in combination with selected treatments (e.g., Inspire Super, polyoxin-D, etc.). This will be compared to standard adjuvants such as oil,

and Nu-Film 17. There will be four replications for each treatment in a randomized complete block design for a factorial experiment. Disease incidence and severity will be evaluated in late spring. Data will be analyzed statistically using ANOVA procedures and mean separation procedures of SAS 9.4.

**3. Evaluate new fungicides for their in vitro activity.** Isolates of the pathogen will be obtained from several locations. To evaluate the in vitro toxicity of selected new fungicides with efficacy in field trials, a new method will need to be evaluated spore germination. Spores will be exposed to media amended with fungicides at selected concentrations, and germination will be assessed after 24-36 hours at 20 C. Suspensions of spores from infected leaves or cultures will be used.

**BENEFITS TO THE INDUSTRY**

Little information is available on the management of peacock spot although the disease is widely distributed and causes sporadic losses in olive growing regions of California. Chemical management is currently based on the use of copper and lime sulfur, two materials that are increasingly being restricted by regulatory agencies at the state and federal levels. Thus, the evaluation of the efficacy and timing of new and older fungicides is needed to provide the industry with alternative treatments for peacock spot management. With Ziram and Inspire Super (difenoconazole+cyprodinil) accepted into the IR-4 program in September 2018, registrations are planned in 2023, and efficacy data needs to be expanded. In 2020, Quadris Top (difenoconazole+cyprodinil) and Syllit (dodine) were accepted into the IR-4 program. Due to the small acreage of olive production in California, registration of any new material will be limited to the IR-4 program. UPI (ziram, polyoxin-D, dodine) and Syngenta (difenoconazole/cyprodinil, or /azoxystrobin) support their respective products on olive. Still, the registration process will take several years to complete for ziram and the Syngenta products, however, polyoxin-D and dodine will be registered in 2021 because they are exempt from tolerance or have an established tolerance in other countries, respectively.

**REFERENCES**

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**Budget Request: (Supplemental to the Olive Knot Proposal)**

Budget Year: 2021

Funding Source: California Olive Commission

Salaries and Benefits:	Post-Docs/RAs	<u>7,000</u>
	Lab/Field Ass't	<u>0</u>
	Subtotal	<u>7,000</u>
	Employees' Benefits	<u>1,500</u>
	Subtotal	<u>8,500</u>
Supplies and Expenses		<u>0</u>
Equipment and University Land and Orchard charges		<u>0</u>
Operating Expenses/Equipment Travel (Davis Campus only)		<u>0</u>
Travel		<u>1,500</u>
Department Account No. _____	<b>Total</b>	<b><u>10,000</u></b>

*James E. Alvarado*

Date: Oct. 28, 2020

Originator's Signature (PI)

*Katherine Borkovich*

Dept. Chair, Kathy Borkovich \_\_\_\_\_  
(Riverside Campus)

Date: Oct. 28, 2020

Liaison Officer \_\_\_\_\_

Date: \_\_\_\_\_

**CALIFORNIA OLIVE COMMITTEE**

**PROJECT PLAN/RESEARCH GRANT PROPOSAL**

Workgroup/Department: Olive / Plant Sciences, UC Davis

Project Year : April 1, 2021 – March 31, 2022. Anticipated Duration of Project: 1 year  
(UC Davis Sponsored Programs Proposal #21-1790)

**Project Title:**

**Characterization of Olive Fruit Abscission Zone in Response to Ethylene Applications and as a Function of Developmental Stage.**

**Project Leaders**

**Dr. Georgia Drakakaki:** Professor, Department of Plant Sciences, 210 Amundson Hall, Mail Stop III, University of California Davis, 1 Shields Ave., Davis CA 95616, (530) 762-1664 [Office], 530-562-5086 [cell] [gdrakakaki@ucdavis.edu](mailto:gdrakakaki@ucdavis.edu)

**Cooperators:**

**Dr. Louise Ferguson:** Extension Specialist, Department of Plant Sciences, 2037 Wickson Hall, Mail Stop II, UC Davis, 1 Shields Ave., Davis CA 95616, (530) 752-0507 [Office], (559) 737-3061 [Cell], [LFerguson@ucdavis.edu](mailto:LFerguson@ucdavis.edu).

**Dr. Giulia Marino:** Extension Specialist, Department of Plant Sciences, 2037 Wickson Hall, Mail Stop II, UC Davis, 1 Shields Ave., Davis CA 95616, (530) 304-4509 [Cell], [Giumarino@UCANR.edu](mailto:Giumarino@UCANR.edu)

Commodity: Olive Relevant AES/CE Project No.

Year Initiated: 2021 Current Funding Request:  
**64,260**

**Problems and Significance:**

Trunk shaker mechanical harvesting of table olives would benefit from increasing fruit abscission without causing excessive leaf loss, ensuring photosynthetic assimilate accumulation for the next season. The overarching goal of this proposal is *to gain a deeper understanding of fruit abscission in response to:* a) exogenous hormonal application and b) fruit developmental stage based on heat unit accumulation. A better understanding of olive fruit abscission will allow precise application of exogenous hormones such as ethylene in order to enable efficient mechanical harvesting without excessive leaf loss.

Fruit abscission involves the separation of cells at defined locations, a process regulated by plant hormones and precisely coordinated with fruit development (Osborne and Morgan, 1989; Xie et al., 2013). The reduction in attachment force between the olive fruit and stem during ripening is of high economic value in the olive industry. Utilization of trunk shaking mechanical harvest is increasing in the California table olive industry, thus the efficiency of mechanical harvesting has received attention in optimizing tree shape management for trunk shaking and chemical applications to reduce the fruit removal force (Hartmann and Reed, 1975; Ferguson et al., 2010).

Fruit abscission is a natural physiological process related to ripening or senescence, potentially for propagation (Osborne and Morgan, 1989). Olive behaves as a typical non-climacteric fruit, thus small amounts of ethylene treatment do not trigger the positive feedback of the ripening process (Rugini et al., 1982). Multiple fruit loosening agents have been tested in olive trees (Burns et al., 2008), many of them were successful in citrus, such as CMNP, ethephon, and methyl jasmonate (Hartmond et al., 2000; Ebel et al., 2009). These studies indicated that application of ethylene forming compounds can induce a significant decrease of the fruit detachment force between the olive fruit and the stem (Burns et al., 2008). Ethylene releasing compounds require an application of 1000 mg/L to effectively reduce the fruit removal force by a 50%, although the compromising side effect of leaf abscission is accompanied by the application.

Goldental-Cohen et al. (2017) successfully enhanced fruit abscission and inhibited the unwanted leaf abscission in a small-scale trial by dipping olive branches in solution containing 0.2% ethrel together with 0.3% ascorbate or butyrate. Anatomical studies indicated the antioxidant counteracted the ROS formation at the leaf peduncles, protecting leaves from abscission triggered by ethylene. Transcriptome analysis of ethephon treated and untreated abscission zones of leaves and fruits also revealed that the genes related to the remodeling of cell wall polysaccharides are differentially regulated in leaf and fruit abscission zone. However, adapted ethephon sprays of this chemical composition did not generate evenly loosened olive fruits for mechanical harvesting in 2016 and 2017 field experiments. *Cumulative work during the past 12 years investigating ethephon applications and its combinations have shown erratic behavior in the fruit removal. Thus a better understanding of fruit abscission is necessary to ensure optimization of mechanical harvesting*

Overall, the organization of molecular and cellular events during olive fruit abscission (FA) remains largely unclear. Lignin deposition was studied at abscission zones in the case of leaf abscission and fruit ripening in olive, and the deposition was found to take place only at the abscission zone of fruits (Polito and Lavee, 1980; Reed and Hartmann, 1976; Parra and Gomez-Jimenez, 2020). While the overall cell wall undergoes modifications at the abscission zone, it has become apparent that a major contribution is due pectin to the polysaccharide modification. In particular, unesterified homogalacturonans are likely to contribute to the cell separations in the abscission zone (Parra et al., 2020). In contrast, cellulose degradation is proposed as a dominant contributor to leaf abscission (LA) in olive Goldental-Cohen et al. (2017).

To understand the cellular mechanisms of olive fruit abscission (FA) induced by ethylene, we will study the anatomical and structural change near the detachment region at ethephon treated and untreated olive variety “Manzanillo”. Studying the cellular mechanisms of olive fruit abscission will help the olive industry to find the molecular targets to manipulate for fruit loosening, and also provide clues for potential alternative chemical spraying agents to test in the future.

**Objectives:**

**The study aims in a mechanistic understanding of fruit abscission under hormonal treatment and as a function of accumulated degree days (DD).**

- 1) Structural characterization of fruit abscission zone (FAZ) based on accumulated degree days (DD).**
- 2) Structural characterization of FAZ under ethephon treatment to determine key cellular changes responsible .**
- 3) Gene expression analysis to identify candidate markers for optimal chemical treatment.**

**Cumulative, the study will allow to predict the timing of chemical application by the changes in FAZ structure and by modeling based on degree days and potential gene expression markers.**

**Experimental Procedures:**

**Materials and methods**

*Plant material.* Samples will be collected within the experiment proposed by Ferguson and Marino proposal entitled: *Timing Ethylene Applications as a Function of Heat Unit Accumulation*. All the experimental details on availability of olive trees are described in the accompanied proposal.

*Harvest and sectioning.* Olive flowers will be tagged on the day of pollination and the AZ samples will be collected from olive fruits subsequently harvested at different specified stages during ripe-fruit AZ cell separation: pre-abscission (unseparated AZ cells) and abscission (partially separated AZ cells) stages (Parra et al. 2020). The fruit AZs sampled for anatomical analysis will be excised by hand to a size of approximately 1 cm<sup>2</sup> consisting of the AZ region as well as the adjacent tissues. The sectioned segments will then be fixed in 4% paraformaldehyde in PBS, cryoprotected in 30% sucrose, and embedded in Tissue-Tek media (Sakura Finetek USA) to be sectioned on a cryostat microtome at 10 microns. Alternatively, fixation will be followed by an ethanol dilution series and a subsequent stepwise exchange of ethanol with LR White. Samples embedded in LR- White resin will be sectioned and prepared for further histochemical analysis using diverse staining procedures for polysaccharides and membranes (Drakakaki et al., 2006; Park et al., 2014; Wilkop et al., 2019)

*Staining* Sectioned FAZ sections will be stained for cellulose, hemicellulose and pectin using specific antibodies using our established methodologies (Wilkop et al., 2019) .

The anatomy of the abscission zone, will be stained with Toluidine Blue, Propidium Iodine. In addition, histochemical stains for specific cell wall components will be used for cell imaging. These will include aniline blue for cellulose, Cos488 for pectin and Fluorol yellow and fuschin for suberin and lignin as previously described (Wilkop et al., 2019; Parra & Gomez-Jimenez 2020 ).

*Imaging.* Stained sections will be examined using our established methodologies (Wilkop et al., 2019). Micrographs will be recorded on the ZEISS LSM/ 700 710 and the Leica SP8 MP microscopes and TEM as needed. Cell structures will be analyzed with the aid of Imaris 8.

*Chemical characterization of polysaccharides.* Cell wall polysaccharide, and other biopolymers will be characterized using established methodologies (Wilkop et al., 2019) using available facilities on campus for monosaccharide and other biopolymer analysis as a support to spactialstaining data obtained from microscopy.

### **Gene expression analysis**

Segments at 4 selected stages under ethylene treatment and control will be subjected for gene expression analysis using RNA-seq technologies. RNA will be extracted from sections. Transcriptome analysis will be performed (Goldental-Cohen et al., 2017) to identify differential expression genes as targets for optimal exogenous hormonal application.

### **Projected Results**

This project will determine the structural/anatomical changes that take place during fruit abscission and provide a basis for models in *abscission and chemical application to assist mechanical harvesting*.

### **Potential Economic Value to California Olive Growers**

*Knowledge in these areas will provide predictive tools for the growers to better handle mechanical harvesting with minimal leaf loss.*

**Budget** *Funds are requested to support a postdoc at 46% salary including benefits (~18%), travel expenses to collect material (~ \$1000) and services and consumables stains, embedding and sectioning material, polymer extraction reagents, RNA seq analysis and instrument recharge expenses (~\$ 23,000).*

### **References**

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**BUDGET REQUEST: 2021**

Budget Year: 2021

Funding Source: COC

**Data Collection: **33,992.00****

Postdoc level III with 3 years of experience at 46% with starting base of \$59,580. (\$27,407)

Benefits rates are 23.5% for 3 months and 24.2% for 9 months and are derived from the UC Davis composite benefits rate schedule. (\$6,585)

The employee will collect samples for analysis and perform fixation, dehydration embedding sectioning, confocal microscopy and polysaccharide and RNAseq analysis. The employee will be assisting in report and manuscript preparation.

**Sub 1 **33,992.00****

**Travel: **1,100.00****

10% of UC Fleet Services for a truck @ \$284/month and average 400 miles per month for 4 months or more + 50.00/month for gas

This truck will be used for trips to the experimental orchard.

**Sub 2. **1,100.00****

**Supplies, Equipment and service charges:**

**\$22,800**

*Supplies:* Laboratory supplies (dyes, antibodies against polysaccharides, fixation and embedding reagents, imaging supplies, nucleic acid and polysaccharide isolation reagents) 9,000.00

*Use of internal facilities:* Use of confocal microscope at UC Davis@ \$35 hour for the duration of the project,

Molecular analysis and RNA sequencing,

Polysaccharide and biopolymer analysis

Maintenance of microtome and sectioning consumables 13,800

**Sub 3** **22,800**

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**Indirect Costs:** **6,368.00**

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Indirect costs are based on 11.0% of total direct costs.

**Sub 4.** **6,368.00**

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**TOTAL BUDGET REQUEST** **\$64,260.00\***

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**Scope of Work**

Drs. Georgia Drakakaki, Minmin Wang:

Responsible for overall coordination and execution of this of the project and data collection. This will include samples for analysis and perform fixation, dehydration embedding sectioning, confocal microscopy and polysaccharide and RNAseq and analyzing the data and writing the final report.

**Approved by:**

UC Davis Sponsored Programs Proposal #21-1790

Title: Characterization of olive fruit abscission zone in response to ethylene applications and as a function of developmental stage

Sponsor: California Olive Committee

Approved

Proposal Deadline: 10/31/2020

Contracts and Grants Analyst – Proposal Team

Office of Research, Sponsored Programs

University of California, Davis

**UNIVERSITY OF CALIFORNIA DAVIS**



\_\_\_\_\_  
Originator's Signature                      10/31/2020  
Date

Agricultural Experiment  
Station

*Grant Low*  
\_\_\_\_\_  
Department Chair                      11-2-2020  
Date

\_\_\_\_\_  
Liaison Officer                      \_\_\_\_\_  
Date

## **PROJECT PLAN/RESEARCH GRANT PROPOSAL**

Project year: 2021

Anticipated Duration of the project: April –November 2021

**Project Leader:** Jim Stewart

Location: Tulare County

Mailing Address: PO Box 1095, Exeter CA 93221

Phone: (559) 730-6243

FAX: (559) 592-4105 E-mail: [jsagipmc@verizon.net](mailto:jsagipmc@verizon.net)

**Project Title:** Southern San Joaquin Valley Olive Fruit Fly Monitoring Project

Cooperating personnel: Bert Quezada, Doug Bigham, Laura Dorskocil, Andrew Quezada

Keywords: Olive Fruit Fly, Monitoring, Traps,

Commodity: Olive

### **PROBLEM AND ITS SIGNIFICANCE:**

The monitoring of Olive Fruit Fly (OLFF) in commercial olive groves in the Southern San Joaquin Valley started in 2001. OLFF is potentially the most significant insect pest in commercial Olive.

### **OBJECTIVES:**

The objective of this project would be to continue the monitoring program of adult OLFF in commercial olive groves in the Southern San Joaquin Valley. Detection and seasonal monitoring of OLFF and the accurate timing of control measures, primarily bait sprays, would be the goal of this project. Correlation of fly collections with fruit susceptibility to infestation would indicate to growers when initial bait treatments should be applied. In addition, monitoring would continue to give growers information on the general OLFF population. This information would be specific for only the groves being monitored and would be available to growers to aid in making OLFF management decisions in their respective groves in the area being trapped.

### **PLANS AND PROCEDURES:**

The locations will be Ivanhoe, Woodlake, Exeter, South Exeter, Tonyville, West Lindsay, Strathmore, Porterville and Terra Bella. In addition, a site in the city of Visalia would also be monitored. All of these sites are in Tulare County where a high percentage of the commercial olives are located in the Southern San Joaquin Valley. Many of the sites have been monitored starting in 2001. All traps will be in place by March 25, 2021. The traps will be read and reported by April 5, 2021 and continue on a weekly basis. Two yellow panel traps with ammonium carbonate bait and male pheromone will be used per site. Traps will be serviced and OLFF counted weekly. Reports detailing the number of male and female Olive Fruit Fly found at each location will be submitted to the California Olive Committee and interested parties within 24 hours on a weekly basis during the project. The program will end November 19, 2021.

## BUDGET REQUEST

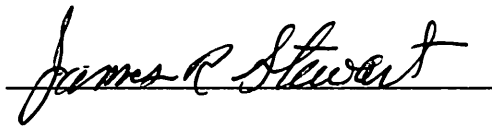
Budget year: April 1, 2021-December 1, 2021

Funding Source: California Olive Committee  
Ag IPM Consultants, Inc.

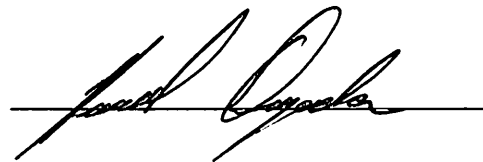
Salaries and benefits:	<u>\$15,900.00</u>
Supplies:	
Traps, bait and pheromone	<u>1,500.00</u>
Travel:	
Mileage to trap sites	<u>2,500.00</u>
Equipment:	<u>0.00</u>
<b>TOTAL</b>	<b><u>\$19,900.00</u></b>

Funding would be split equally between the above listed funding sources.

**Total funding from the California Olive Committee would be: \$9,950 \***



James R. Stewart  
Project leader  
Ag IPM Consultants, Inc  
PO Box 1095, Exeter CA 93221  
Phone: (559) 730-6243  
Fax: (559) 592-4105



Bert Quezada  
Senior Pest Control Advisor  
Ag IPM Consultants, Inc  
PO Box 1095, Exeter CA 93221  
Phone: (559) 936-0102  
Fax: (559) 592-4105

\*The reason for the increase from previous years is one of the funding sources (Nutrien Ag Solutions) decided not to participate.

**Project Plan/ Research Grant Proposal**

Project Year: 2021

**Project Leader:** Ernie Simpson

Mailing Address: 320 County Road 15 Orland, California 95963

Phone: 530-865-9829 Cell: 530-518-4685

E-mail: [ernsimp17@sbcglobal.net](mailto:ernsimp17@sbcglobal.net)

Commodity: Olive

**Problem and its Significance:**

Since the detection of Olive Fruit Fly in California in 1998, it has been a concern to olive growers in commercial orchards; preventative sprays are necessary. Trapping to monitor the Olive Fruit Fly populations in individual orchards is recommended. This will allow growers and PCA's to follow trends to their orchards and help evaluate spray program efficacy. Having an idea of area-wide population trends will help growers and PCA's interpret the results from their orchards.

**Objectives:**

- 1: Provide timely information to area growers regarding area-wide olive fruit fly population trends.
- 2: Continue to develop a historical perspective of olive fruit fly populations for the area.

**Plans and Procedures:**

Starting in early April plastic McPhail traps using Torula yeast tablets dissolved in water as the bait will be placed in one tree at 12 sites (6 in Glenn County and 6 in Tehama County). The same sites that have been used in previous years will be monitored again to allow for comparison of current years trap catches to previous years. Earlier work in Glenn and Butte Counties has shown that the plastic McPhail traps catch more flies than the commonly used yellow panel trap. Traps will be checked and flies counted weekly. The results and field observations will be posted on the Glenn County UC website ([Http://ceglenn.ucdavis.edu](http://ceglenn.ucdavis.edu)) and reported via email to the COC for further distribution. Trapping results will be reported as male and female flies for individual traps and combined and averaged by site for a graphic presentation of the data. Trapping and reporting will be continued through November or until trap catches decline for the year.

**Budget Request**

Budget Year: 2021

Funding Source: California Olive Committee

Salaries	\$4800
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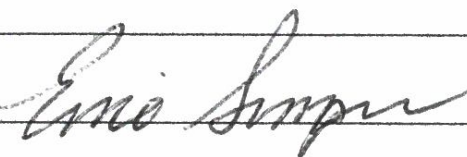
Supplies and Expenses: Trapping Supplies	\$ 300
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Travel 2545 mi. @ \$.55/mi.	\$1400
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This may vary due to fuel prices

Total	\$6500
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Originator's Signature



Ernie Simpson

**\*\*\*ACTION REQUIRED\*\*\***

**FROM:** COC RESEARCH SUBCOMMITTEE

**SUBJECT:** 2021 RESEARCH PROJECTS

**RECOMMENDATION:** THAT the Subcommittee approve various research projects for 2021.

**BACKGROUND:** Each year the Research Subcommittee approves various research projects funded by the Full Committee. The Subcommittee must determine which proposed projects to recommend to the Full Committee for funding. An estimated budget of \$298,360.42 is proposed based on the submitted projects.

**2021 RESEARCH PROPOSALS FOR THE CALIFORNIA OLIVE COMMITTEE**

<b>TOPIC</b>	<b>LEADERS</b>	<b>AMOUNT</b>
Timing Ethylene Applications as a Function of Heat Unit Accumulation	Louise Ferguson Giulia Marino	\$24,470
Managing Alternate Bearing in Olive with PGRs and Pruning	Carol Lovatt Elizabeth Fichtner	\$27,230
Combining Trunk Shaking and Canopy Shaking for a Highly Efficient, Low-Cost Olive Harvester-Part 2	Reza Ehsani Louise Ferguson	\$69,997
Precise Water Management Strategies for Table Olive Orchards in California	Giulia Marino Louise Ferguson	\$54,303.42
Epidemiology and Management of Olive Knot Caused by Pseudomonas Savastanoi pv. Savastanoi	J.E. Adaskaveg	\$31,650
Management of Foliar Diseases of Olive- A. Olive Knot and B. Evaluation of new fungicides for control of olive leaf spot	J.E. Adaskaveg	\$10,000
Characterization of Olive Fruit Abscission Zone in Response to Ethylene Applications and as a Function of Developmental Stage	Georgia Drakakaki	\$64,260
Southern San Joaquin Valley Olive Fruit Fly Monitoring Project	Jim Stewart	\$9,950
Sacramento Valley Olive Fruit Monitoring Project	Ernie Simpson	\$6,500
2020 NCE Managing Alternate Bearing in Olives with PGRs and Pruning	Carol Lovatt Elizabeth Fichtner	\$9,292.80
2020 NCE Control of Overwintering Olive Fruit Fly Using Insect Pathogenic Fungi	Frank Zalom Joanna Fisher	\$6,878.4
Total * budget estimate; actual budget pending on results		\$298,360.42- Without NCEs \$314,531.62- With NCEs

**FISCAL IMPACT:** Unknown

**\*\*\*ACTION REQUIRED\*\*\***

**FROM:** COC RESEARCH SUBCOMMITTEE

**SUBJECT:** NO-COST EXTENSIONS

**BACKGROUND:** Each year, researchers will request a no-cost extension should their program run past the fiscal year. COC staff asks that the Committee grant authority to the Executive Director in conjunction with the Chairman to approve requests for no-cost extensions.

- For 2020 Research Projects there are 2 requests for NCE's:
  1. Managing Alternate Bearing in Olive with PGRs and Pruning-Carol Lovatt and Elizabeth Fichtner
  2. Control of Overwintering Olive Fruit Fly Using Insect Pathogenic Fungi-Frank Zalom and Joanna Fisher

September 24, 2020

To: California Olive Committee

Attention: Elise Oliver, Program Supervisor  
California Olive Committee  
2565 Alluvial Avenue, Suite 152  
Clovis, CA 93611  
T: (559) 456-9096 | F: (559) 456-9099  
[www.calolive.org](http://www.calolive.org)

From: Carol J. Lovatt  
Professor of Plant Physiology, Emerita, and Plant Physiologist  
Professor in the Graduate Division  
Department of Botany & Plant Sciences-072  
University of California-Riverside

Re: Request for a No-Cost Extension (NCE) through June 30, 2021

Project: Managing Alternate Bearing in Olive with Plant Growth Regulators (PGRs) and Pruning

Elizabeth Fichtner and I are requesting a no-cost extension (NCE) for our current 2020 COC-funded project, "Managing Alternate Bearing in Olive with Plant Growth Regulators (PGRs) and Pruning", through June 30<sup>th</sup>, 2021.

We request a no-cost extension for the following reasons:

- 1) Our olive research again this year, runs from pre-bloom (February) of the funded year (2020) to full bloom (April) of the following year (2021).
- 2) The objectives for funded year 2020 of our COC project include the second half of the treatments that are applied in the following spring (2021) to trees that received the first half of the treatment in 2020.
- 3) The objectives for the 2020 funded year of our COC project also require the evaluation of bloom the following spring (2021) to quantify the efficacy of the treatments applied in 2020.

Thank you for your assistance with our request.

October 2, 2020

To: California Olive Committee

Attention: Elise Oliver, Program Supervisor  
California Olive Committee  
2565 Alluvial Avenue, Suite 152  
Clovis, CA 93611  
T: (559) 456-9096 F: (559) 456-9099  
[www.calolive.org](http://www.calolive.org)

From: Frank G. Zalom and Joanna Fisher  
University of California, Davis

Re: Request for a No-Cost Extension (NCE) through June 30, 2021

Project: Control of Overwintering Olive Fruit Fly Using Insect Pathogenic Fungi

We would like to request a no cost extension for our 2020 COC research project entitled "*Control of Overwintering Olive Fruit Fly Using Insect Pathogenic Fungi*".

The most intense research period for us is between October and April of each year due to the life cycle of olive fruit fly and the focus of our research which is attempting to control the overwintering population. As might be expected, most of our expenditures occur during this period. Unfortunately, this timing is not in sync with the annual funding cycle for the COC grant. We have intentionally preserved funds from the 2020 COC research grant to enable us to continue with the associated lab and field work that occurs through winter and spring, but this will require the approval of a no cost extension of these funds.

Thank you and the Research Subcommittee for considering our request.

**\*\*\*ACTION REQUIRED\*\*\***

**FROM:** COC RESEARCH SUBCOMMITTEE

**SUBJECT:** INTER-ITEM TRANSFERS OF THE RESEARCH BUDGET

**RECOMMENDATION:** THAT the Committee grant authority to the Executive Director and Chairman for inter-item transfers of the Research Budget.