

AGENDA

California Ripe Olive Research Subcommittee Meeting ZOOM/Conference Call

**NOVEMBER 10, 2021
10:30 AM**

Zoom Meeting:

<https://us02web.zoom.us/j/83457081282>

Telephone:

+1669-900-6833

Meeting ID: 834 5708 1282 #

- I. Call to Order**
 - a. Roll Call - pg. 2
 - b. Research Subcommittee Chairman's comments
 - c. Approval of July 20, 2021 Minutes (**action item**) -pg. 3
- II. Discussion and Review of 2021 Projects - pg. 8**
- III. Presentation of 2022 Proposals - pg. 59**
- IV. Presentation from Valent - pg. 114**
- V. Approval of 2022 Budget (**action item**) - pg. 129**
 - a. Closed Session
- VI. Approval of Authority to the Executive Director and Chairman to approve No-Cost Extensions (**action item**) - pg. 130**
- VII. Approval of Authority to the Executive Director and Chairman for Inter-Item Transfer of the Research Subcommittee Budget (**action item**) - pg. 131**
- VIII. Other Business**
- IX. Adjournment**



2021-2023 Research Subcommittee

Producer Members:

Carolina Burreson
Michael Silveira
Chris Henderson
Andy Weinrich
Ed Curiel
Vito DeLeonardis
Giulio Zavolta
Pat Ricchiuti
Galen Pfeiffer
Mark Heuer

Handler Members:

Dennis Burreson-Chairman
John Pieretti
Tomas Masanes Autard
Julia Tinsley
Jacob Peters



II. Review of 2020 Research Final Reports

2020 RESEARCH PROJECTS FOR THE CALIFORNIA OLIVE COMMITTEE

- Projects in red had No Cost Extensions and are now complete. Final Reports can be found in the following pages of the packet and also on the COC website under the ‘Industry’ tab.

Researcher	Project	Amount
Reza Ehsani Louise Ferguson	Combining trunk shaking and canopy shaking for a highly efficient, low cost olive harvester.	\$92,699
Debra Keenan	Evaluation of new chemistries to control Olive Fruit Fly	\$25,000
Carol Lovatt Elizabeth Fichtner	Managing Alternate Bearing in Olive with PGRs and Pruning	\$23,232
Frank Zalom Joanna Fisher	Control of overwintering olive fruit fly using insect pathogenic fungi	\$17,196
J. E. Adaskaveg	Epidemiology and management of olive knot caused by Pseudomonas savastanoi pv.savastanoi	\$16,650
J. E. Adaskaveg	Management of foliar diseases of olive (peacock spot)	\$10,000
Jim Stewart	Southern San Joaquin Valley Olive Fruit Fly Monitoring Project	\$6,400
Ernie Simpson	Sacramento Valley Olive Fruit Monitoring Project	\$6,500
	Total	\$197,677.00

III. Update on CA Specialty Crop Block Grant Program Applications

- On July 13, 2021 the California Department of Food and Agriculture (CDFA) announced they will be accepting proposal for one-time specialty crop block grants. In addition to the regular SCBGP funding authorized by the Farm Bill, the United States Congress has awarded additional one-time SCBGP funding to state department of agriculture due to the COVID-19 impacts on the food system.
- The COC will be submitting two grant proposal ideas:
 - Machine harvesting of existing mature trees coupled with a cost of production study.
 - A sustainability assessment in partnership with the Olive Oil Commission.



IV. Discussion and Approval of 2022 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 liaisons to request proposals from researchers. Proposals will be reviewed for funding in November by the subcommittee.
- On the following page are the 2021 Research Priorities.

2021 RESEARCH PROJECTS FOR THE CALIFORNIA OLIVE COMMITTEE

Researcher	Project	Amount
Giulia Marino Louise Ferguson	Timing Ethylene Applications as a Function of Heat Unit Accumulation	\$24,470
Carol Lovatt Elizabeth Fichtner	Managing Alternate Bearing in Olive with PGRs and Pruning	\$27,230
Giulia Marino Louise Ferguson	Precise Water Management Strategies for Table Olive Orchards in California	\$54,303
Reza Ehsani Louise Ferguson	Combining trunk shaking and canopy shaking for a highly efficient, low cost olive harvester-Mature Trees	\$69,997
J. E. Adaskaveg	Epidemiology and management of olive knot caused by <i>Pseudomonas savastanoi pv.savastanoi</i>	\$16,650
J. E. Adaskaveg	Management of foliar diseases of olive (peacock spot)	\$10,000
Georgia Drakakaki	Characterization of Olive Fruit Abscission Zone in Response to Ethylene Applications and as a Function of Developmental Stage	\$64,260
Jim Stewart	Southern San Joaquin Valley Olive Fruit Fly Monitoring Project	\$9,950
Ernie Simpson	Sacramento Valley Olive Fruit Fly Monitoring Project	\$6,500
Contingency Fund		\$20,000.00
	Total	\$303,360

2022 Research Priorities

1. Olive fruit fly trapping for North and South
2. Olive knot (COC & OGCC)
3. Drone technology/satellite mapping (Ceres)
4. Deficit irrigation
5. Mechanical harvesting on existing and new high density orchards
6. Loosening Agents
7. Peacock Spot



8. Managing alternate bearing / Nutrient management/irrigation
9. Olive DNA evaluation
10. Canopy Management
11. Olive fruit fly alternative solutions

- **MOVED by Pat Ricchiuti, duly seconded by Mike Silveira and carried THAT the Research Subcommittee approve the 2022 Research Priorities. (MOTION 7-20-21 #2)**

V. Other Business

NONE

VI. Adjournment

Chairman Dennis BURRESON adjourned the Research Subcommittee meeting at 9:56 a.m.

Todd W. Sanders
Executive Director
California Olive Committee



Summary of Motions for July 20, 2021

Motion 7-20-2021 #1

APPROVED

MOVED by Pat Ricchiuti, duly seconded by John Pierretti, and carried THAT the minutes for January 22, 2021, be approved as presented.

Motion 7-20-2021 #2

APPROVED

MOVED by Pat Ricchiuti, duly seconded by Mike Silveira and carried THAT the Research Subcommittee approve the 2022 Research Priorities.

*****INFORMATION ONLY*****

FROM: COC RESEARCH SUBCOMMITTEE

SUBJECT: PROGRESS REPORTS FOR 2021

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.

2021 Research Projects

Researcher	Project	Amount	Finalized MOU	Paid thus far	% Paid	No Cost Extension
Giulia Marino Louise Ferguson	Timing Ethylene Applications as a Function of Heat Unit Accumulation	\$24,470	2/22/2021	\$14,682	60%	
Carol Lovatt Elizabeth Fitchner	Managing Alternate Bearing in Olive with PGRs and Pruning	\$27,230	3/19/2021	\$16,338	60%	
Giulia Marino Louise Ferguson	Precise Water Management Strategies for Table Olive Orchards in California	\$54,303	2/22/2021	\$32,581.80	60%	
Reza Ehsani Louise Ferguson	Combining trunk shaking and canopy shaking for a highly efficient, low cost olive harvester-Mature Trees	\$69,997	2/26/2021	\$41,998.20	60%	
J. E. Adaskaveg	Epidemiology and management of olive knot caused by Pseudomonas savastanoi pv.savastanoi	\$16,650	6/3/2021	\$9,990	60%	
J. E. Adaskaveg	Management of foliar diseases of olive (peacock spot)	\$10,000	6/3/2021	\$6,000	60%	
Georgia Drakakaki	Characterization of Olive Fruit Abscission Zone in Response to Ethylene Applications and as a Function of Developmental Stage	\$64,260	3/11/2021	\$38,556	60%	
Jim Stewart	Southern San Joaquin Valley Olive Fruit Fly Monitoring Project	\$9,950				
Ernie Simpson	Sacramento Valley Olive Fruit Fly Monitoring Project	\$6,500				
	Contingency Fund	\$20,000.00				
	Total	\$303,360		\$160,146.00		

CALIFORNIA OLIVE COMMITTEE

INTERIM REPORT 10/15/2021

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.

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

Cooperators:

Dr. Georgia Drakakaki: Professor, UCDavis

Dr. Reza Ehsani: Professor, UC Merced

Dr. Richard Rosecrance: Professor, Chico State University

Mr. William H. Krueger: Farm Advisor Emeritus

Luke Milliron: Butte County Farm Advisor

Emily Santos: Assistant Specialist, UC Davis

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 1st – October 31st 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 were secured:

1. Nickels Soils Laboratory moderate density (202 tree/acre) orchard in Colusa County: 1_Map attached
 - a. Four replications, three rows wide, 3 trees each for treated and control.
 - b. Total 36 treated and 36 controls: 72 trees total.
2. Glenn County Orchard, 180 trees per acre, trained for trunk shaking harvesting: 2_Map attached
 - a. Three replications repeated in three row wide, 3 trees each for treatment and control.
 - i. 54 trees total, 9 trees at each treatment timing.

Temperature Logging and Growing Degree Day (GDD) Accumulation Calculation

Local data loggers that measured temperature accumulation were used for Growing Degree Day (GDD) accumulation.

At full bloom the loggers started 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 ~ 1 cm in length, 3 sets of 100 olives/row were be collected weekly:

- Average size by volume was be determined by water displacement and caliper measurement

Fruit Removal Force (FRF) Measurements:

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

Ethephon Treatment

When fruit removal force started declining, and/or fruit showed color, treatments were started:

3 rows x 3 trees = 9 trees per treatment and control each, sprayed to drip @ 100 GPA rate

1. 1500 PPM Ethephon 0.25% surfactant*
2. Water control and 0.25% surfactant

1. The ethylene was sprayed on September 10th, 13th and 16th at Nickels Soils Laboratory and September 9th, 13th and 16th at Burreson Ranch.

Harvesting

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

Trees were hand gleaned after harvest and fruit weighed but not graded

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

$$\begin{aligned} & \textit{Efficiency} \\ & = \frac{\textit{Mechanically harvested (lb)}}{\textit{Manually harvested (lb)} + \textit{Mechanically harvested (lb)}} \\ & \times 100 \end{aligned}$$

Statistical Analysis:

An Analysis of Variance with and LSD means separation test compared: 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 in March. The trees will be rated visually for leaf drop on a 1-3 scale: 1= none, 2 = visible, 3 = severe.

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%.

Results as of 10/15/2021:

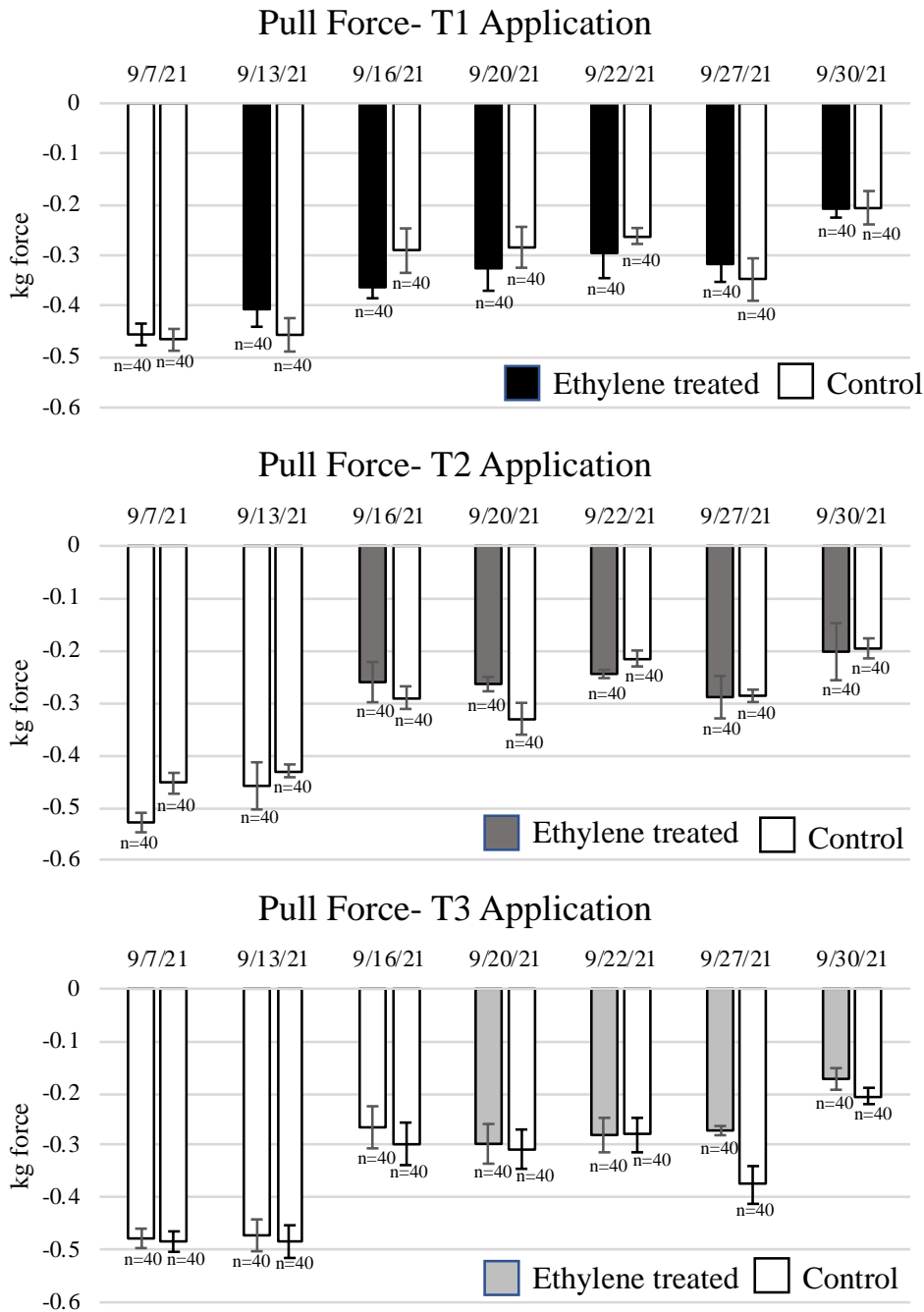
All field procedures have been completed with the exception of the visual estimates of leaf loss to be done in late March. The results have been analyzed: as can be seen below there are three major conclusions: consistent at two locations.

- 2. The ethylene had no effect on fruit removal force at any of the three application times: T1, T2 or T3 in both orchard locations; Nickels Soils Laboratory in Colusa County and Burreson Ranch in Orland County.*
- 3. The trunk shaking harvester harvested olives with approximately 50-60% efficiency at Nickels Soils laboratory with an ENE pistachio trunk shaker and 65-80% efficiency in Burreson Ranch with a Coe pistachios trunk shaker.*
- 4. There were no statistically significant differences in crop value, which ranged from \$1320 – 1340 at Nickels Soils Laboratory and \$1200.00 per ton from Burreson Orchards, among the three ethylene timing treatments.*

While this trial detected no difference in harvest efficiency with ethylene treatments it did demonstrate 75 – 80% harvest efficiency with a trunk harvesting shaker.

A more detailed final report will be submitted in December 2021.

Nickels On

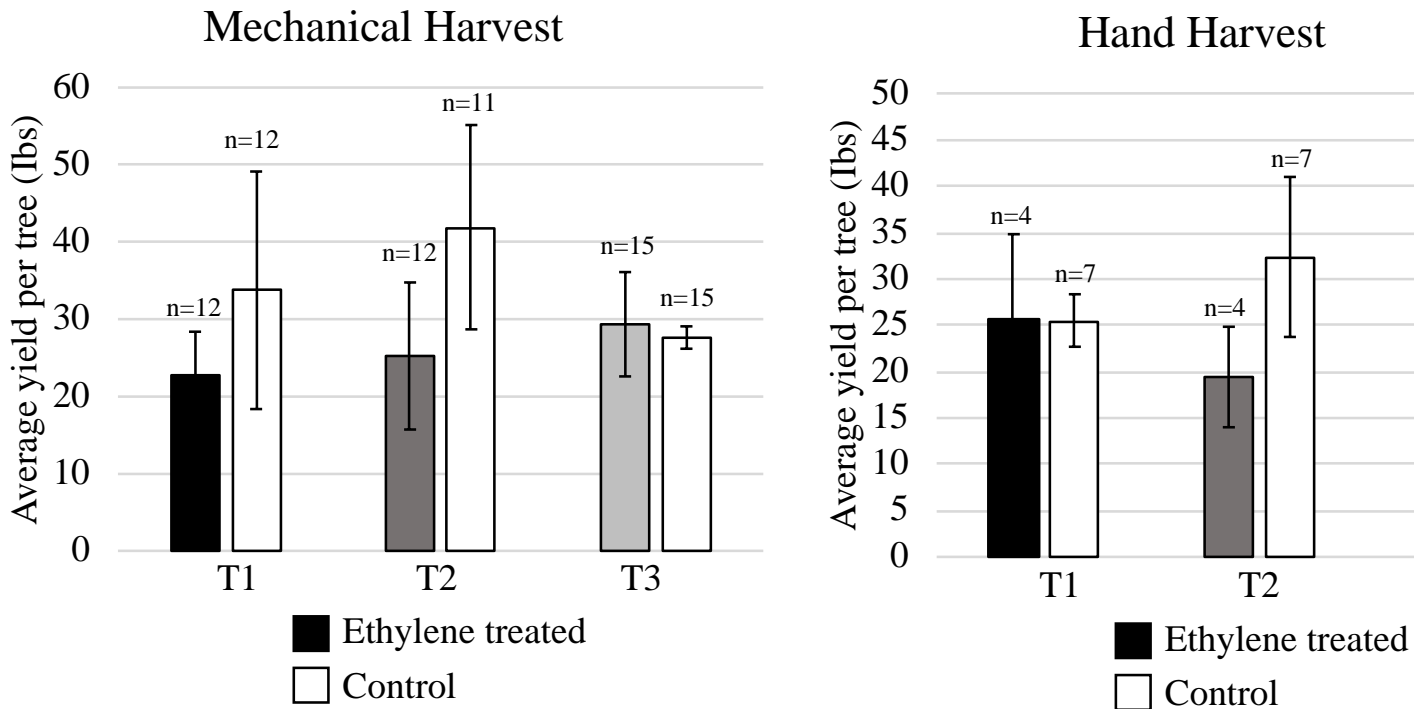


error bars represent
standard deviation calculated
from replicated plots
for a total of (n) number

Figure 1. This figure shows the decrease in pull force over time at three different spray times; T1, T2 and T3. A can be seen in the

three timings above the pull forced in both the untreated and ethylene treated trees decreased from approximately half a kilo (1.10 pounds) to approximately 0.20 kilo (0.44 pound) from September 7th to September 30th. There were no consistently statistically significant differences in the decrease in pull force over time in trees treated with ethylene versus untreated controls.

Nickels Orchard

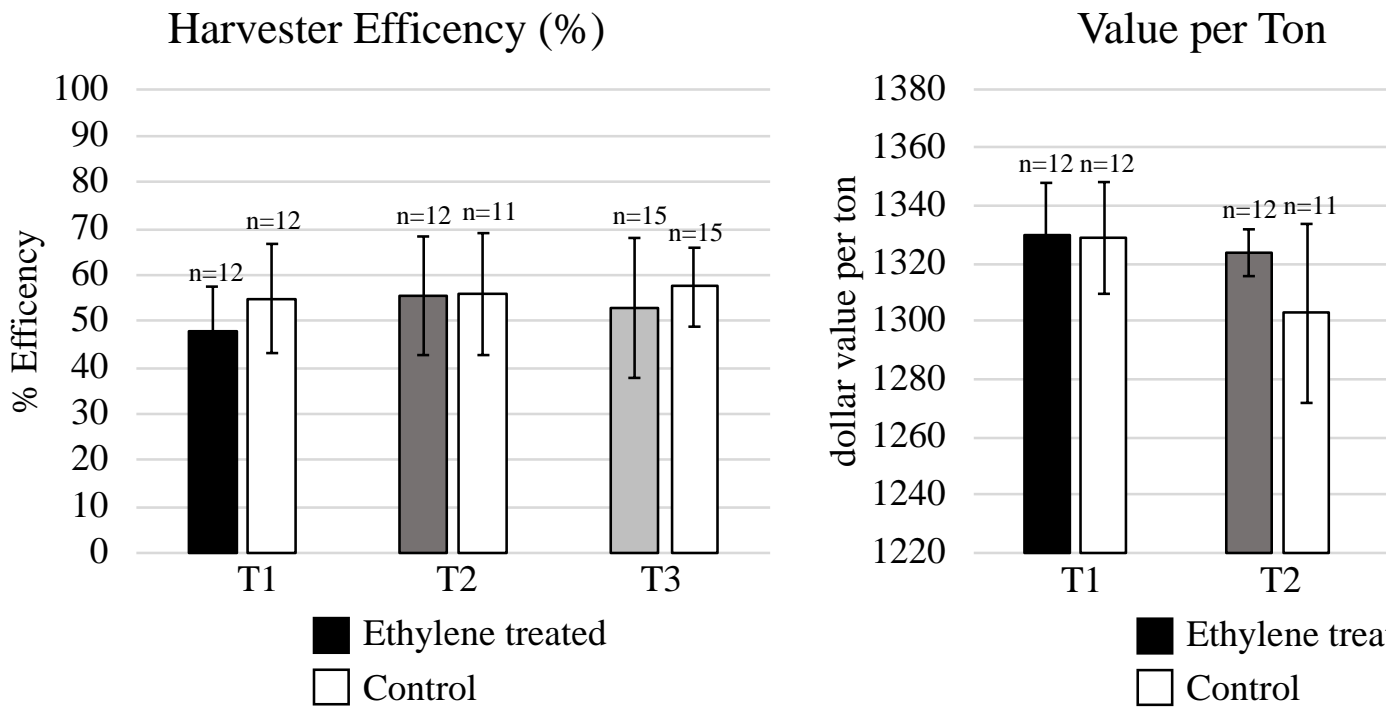


error bars represent +/- standard deviation calculated across four replicated plots per treatment using a total of (n) number of trees

error bars represent +/- standard deviation calculated across four replicated plots per treatment using a total of (n) number of trees

Figure 2. This figure demonstrates there was no statistically significant difference among the ethylene treatment timings in the weight of olives harvested by hand or mechanically, or the total yields per treatment, versus untreated control trees.

Nickels Orchard

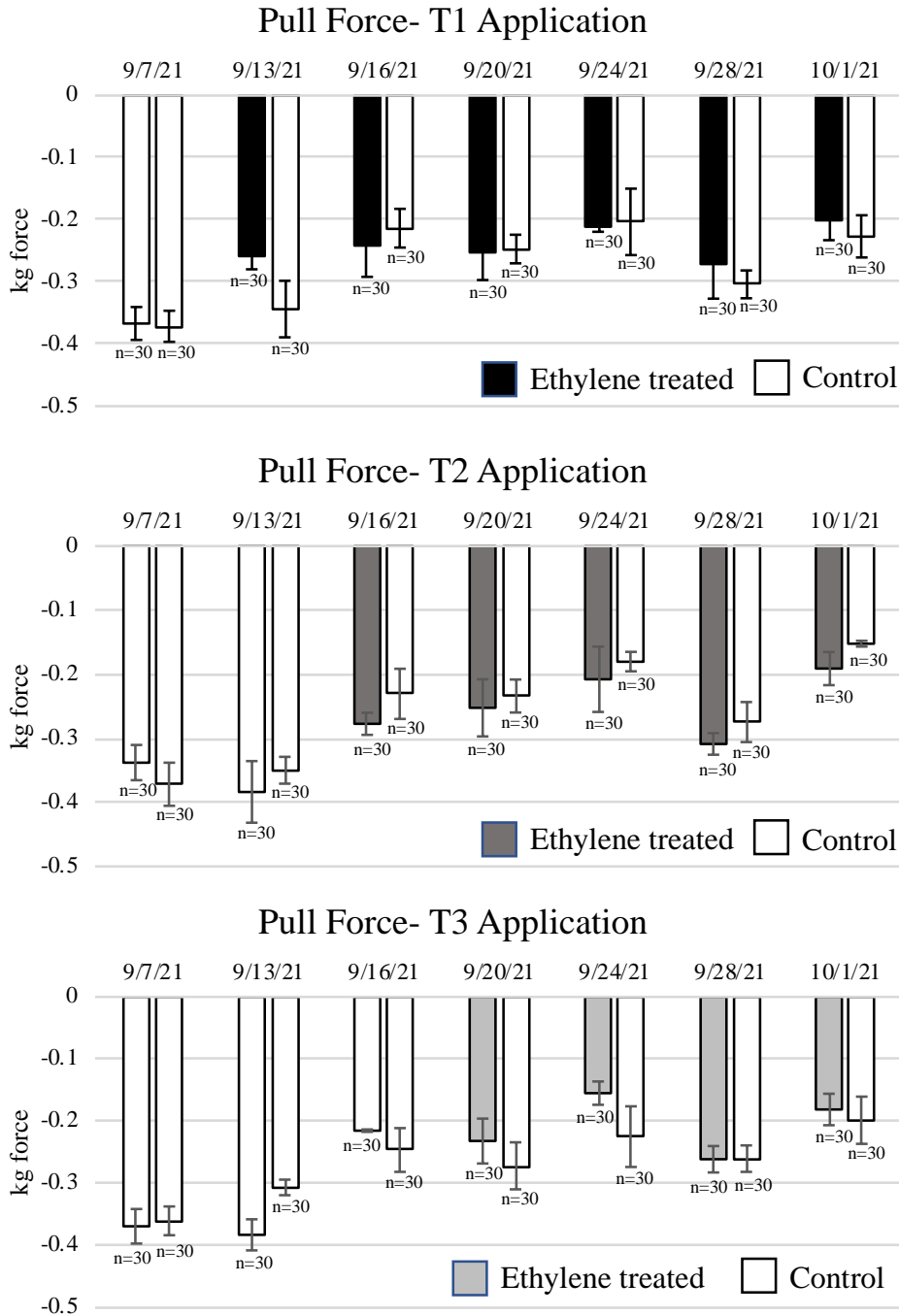


error bars represent +/- standard deviation calculated across four replicated plots per treatment using a total of (n) number of trees

error bars represent +/- standard deviation calculated across four replicated plots per treatment using a total of (n) number of trees

Figure 3. This figure demonstrates that there was no statistically significant differences in trunk shaking efficiency among the three ethylene treatments, all averaged approximately 50-60%, versus untreated control trees. The values per ton ranged from \$1320-1340

per ton and were not significantly different among treatment timings.

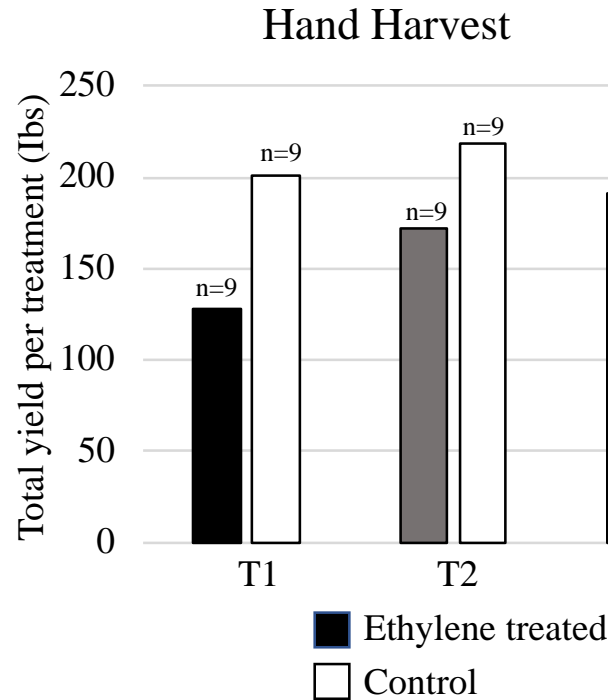
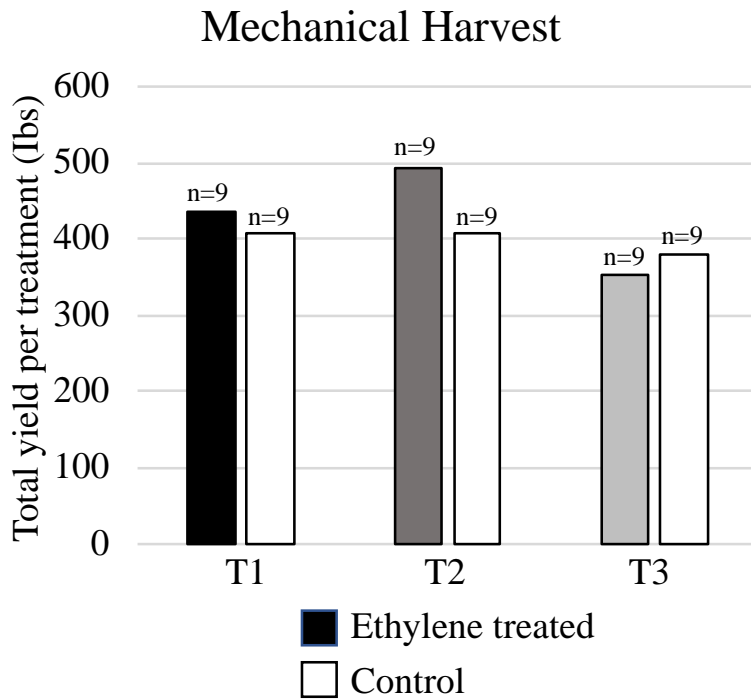


error bars represent standard deviation calculated from replicated plots per treatment per date for a total of (n) number of plots

Figure 4. This figure show the decrease in pull force over-time at three different spray times; T1, T2 and T3. A can be seen in the

three timings above the pull force in both the untreated and ethylene treated trees decreased from half a kilo (1.10 pounds) to approximately 0.20 kilo (0.44 pound) from September 7th to October 1st. There were no consistently statistically significant differences in the decrease in pull force over time, among treatments and versus untreated controls.

Burreson Orchard

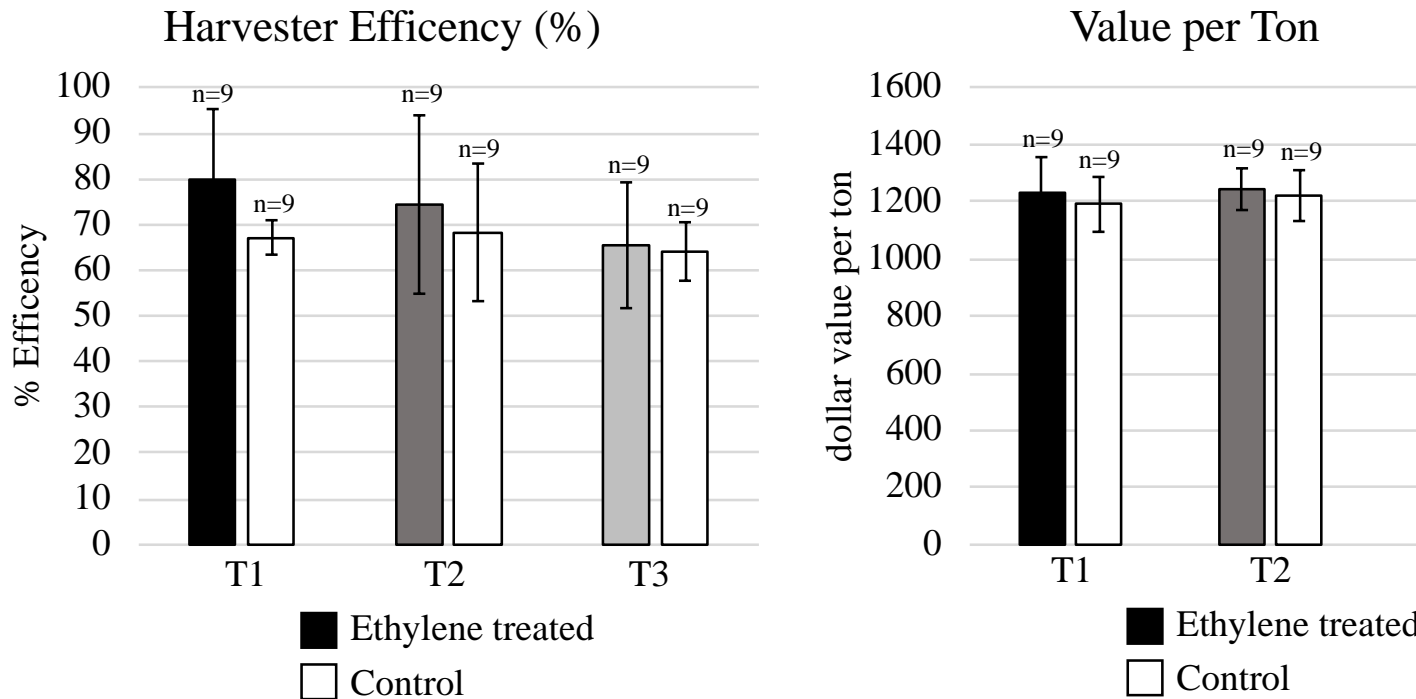


yield calculated across three replicated plots per treatment using a total of (n) number of trees

yield calculated across three replicated plots per treatment a total of (n) number of trees

Figure 5. This figure demonstrates there was no statistically significant differences among the ethylene treatment timings, or versus controls, in the weight of olives harvested by hand or mechanically, or the total yield per treatment.

Burreson Orchard



error bars represent +/- standard deviation calculated across three replicated plots per treatment using a total of (n) number of trees

error bars represent +/- standard deviation calculated across three replicated plots per treatment using a total of (n) number of trees

Figure 6. This figure demonstrates that there were no statistically significant difference in trunk shaking efficiency among the three ethylene treatment times, or versus the untreated controls, all averaged approximately 65-80 %. The values per ton averaged

slightly over \$1200 per ton for all ethylene treatments and untreated controls. Neither parameter was statistically significantly different among treatment timings or versus untreated controls.

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.: 8th Int. Olive Symp. Oct. 10th – 14th 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**

TOTAL BUDGET REQUEST **24,470.00***

- This experiment will be done in cooperation with the following trials:
- 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

UNIVERSITY OF CALIFORNIA DAVIS



Originator's Signature

10/30/2020
Date

Agricultural Experiment
Station

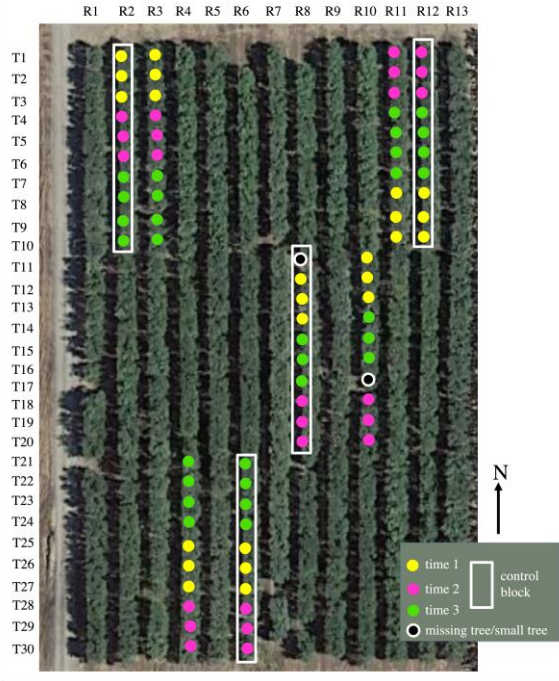
Department Chair

Date

Liaison Officer

Date

Nickles Olive Orchard (38.966229, -122.076959)
Ethylene application on 10 ft topping hedgerow trial



Burreson Olive Orchard (39.773001, -122.168849)
Ethylene application



**University of California
Division of Agricultural Sciences**

PROJECT PLAN/RESEARCH GRANT PROPOSAL PROGRESS REPORT

Project Year: 2021 Anticipated Period of Performance: year 2 of 3 requested

Project Leaders:

Carol Lovatt, Ph.D.

Department of Botany and Plant Sciences-072

University of California

Riverside, CA 92521-0124

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Elizabeth Fichtner, Ph.D.

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4437 S. Laspina St.

Tulare, CA 93274

(O) 559-684-3310 FAX: 559-685-3319 (M) 559-684-2057

ejfichtner@ucdavis.edu

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

Cooperators:

Lindcove REC

‘Manzanillo’ table olive orchard, Lindcove

Kurt Schmidt, Lindcove Research and Extension Center, 22963 Carson Avenue, Exeter, CA 93221; Phone: 559-592-2408, ext. 153; Email: krschmidt@ucanr.edu

Overview and summary of our research results to date: Alternate bearing (AB), production of a heavy, high yield "on crop" followed by a light, low yield "off crop", is a significant economic problem. In ON-crop years, trees produce a large number of small size fruit with reduced commercial value. In OFF-crop years, trees produce large fruit, in some cases too large, but there are too few fruit to provide growers with a good income. In addition, our research has documented that fruit quality is reduced in off-crop years. The large fruit of OFF-crop trees turn black earlier in the season further exacerbating the problem of too few commercially valuable fruit. For olive, the ON-crop takes longer to mature, attain size and accumulate oil. The delayed harvest further reduces floral intensity the following spring. Alternate bearing trends often occur beyond the tree or orchard level, but rather synchronize across geographic regions, particularly in systems where environmental conditions affect crop load (i.e., heat at bloom in ‘Manzanillo’ orchards). An industry-wide shortage of fruit in the OFF-crop year has a negative economic impact on every step in the production chain from farm to consumer, including orchard management, harvesting, packinghouse/processor operations, manufacture of value-added products, marketing, and consumer prices, the summation of which jeopardizes the stability and sustainability of the olive industry. Climate is the major factor initiating AB. High or low temperatures, water-deficit stress or excessive winter rain causing

soil hypoxia etc. that significantly reduce 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.

In an alternate bearing orchard, return bloom is dramatically reduced on bearing shoots of ON-crop trees, the majority of shoots on ON-crop trees, due to the combined effects of the total number of 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. These two combined effects of fruit in the ON crop (i) inhibit summer vegetative shoot growth and thereby reduce the number of nodes that can produce floral (inflorescence) buds the following spring, as first demonstrated by Sibbett (2000) and confirmed by our research, (ii) increase floral bud abscission, (iii) inhibit flowering by preventing transcription of key genes required for inflorescence development and flower formation, and (iv) reduce bud break in the spring following the ON-crop year, all of which were first identified by our COC funded research (Fichtner and Lovatt, 2018; Fichtner et al., 2017; Chao, 2014). **Note** that for 'Manzanillo' olive, the localized effect of fruit set on a shoot is a stronger negative effect on each of the four return bloom parameters listed above than the total number of fruit on the tree (crop load effect). Thus, 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. 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 as 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. Thus, the overall goal of our research is to develop a management strategy that increases the number of non-bearing shoots to the degree necessary to maximize total yield and yield of commercially valuable size fruit annually such that the sum of two annual yields is greater for our treated trees than the sum of the ON/OFF yields of an alternate bearing cycle.

The research we conducted during the past 4 years compared the efficacy of a PGR chemical flower thinning treatment (naphthaleneacetic acid [NAA]) applied at full bloom and mechanical pruning (hedging) done after fruit set (28 days after full bloom) to increase the number of non-bearing shoots on ON-crop trees to increase return bloom and yield compared 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 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 2-year cumulative total yield and 2-year cumulative yield of commercially valuable size fruit (medium+large) to greater than the sum of a 2-year ON/OFF cycle in an alternate bearing orchard. Our results demonstrated that reducing crop load with NAA or pruning one side of the tree and then the other side give similar results in most years and that both are best done every other year, not annually, and not on a rigid schedule. For examples, (i) 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 (ii) the crop load reducing treatments should be used out of sequence when it is necessary 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 goal for 2021 for a set of trees was to combine the fruit thinning strategies with the cytokinin-PGR (natural product that does not require registration) treatment 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. The objective was to increase the 2-year cumulative yield of commercially valuable size fruit to greater than the sum of the ON-/OFF-crop yields in an alternate bearing cycle. The 2-year cumulative yields for commercially valuable medium+large size fruit achieved in our research thus far suggest that this goal is attainable.

Objectives for 2021 (Year 2). *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 tested the AMVAC NAA product, Olive Stop[®], applied according to the manufacturer's instructions. To meet this objective, we have also removed fruit by pruning (mechanical hedging) one side of the tree and then the other side every other year. *Note* that Year 2 of this research was the year in which the treatments were not applied; they will be applied in 2022. *Objective 2* – To maintain uniform high yields of commercially valuable size fruit we combined 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 at return bloom and fruit size (Fichtner and Lovatt, 2018; Fichtner et al., 2017). This treatment was applied to one set of trees that will be treated with NAA on the west side of the tree in 2022 and to a another set of trees that will be pruned on the west side of the tree in 2022. Applications were made in February just prior to spring bud break (identified in earlier research as the optimal application time to increase spring bud break and inflorescence number at full bloom) and again just prior to summer vegetative shoot growth (early July, 7 July), and will be applied again just prior to spring bud break in February 2022. The results of treatments described under Objectives 1 and 2 were 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. 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.

Research Accomplishments for 2021.

1) Treatment effects on return bloom in 2021.

A visual estimate of bloom was made for the east and west sides of each tree before treatments were applied in 2021 to determine the effect of the previous year's treatments on return bloom. *Note* that the spring cytokinin-PGR treatment to increase spring bud break and flowering was applied in February to trees in treatments 5 and 6 and thus, was applied before the bloom estimates were done. The results for the east and west sides of each tree were averaged to give an average value per tree. Additionally, the estimated bloom results for the east and west sides of the trees were added to give a sum for the tree. Bloom estimates for 2021 (done prior to 2021 treatment applications, except as noted above) provided important information on the effects of the 2020 treatments on return bloom in 2021 and provide evidence of the benefit of the spring cytokinin treatment to enhance bloom (Table 1). The bloom estimate data for 2020 documented that trees treated with NAA or pruned annually had significantly lower average and sum of east and west bloom estimates (trees in treatment 5 and 6) compared with trees treated with NAA or pruned every other year (trees in treatments 2 and 3); compare the average/sum for trees treated with NAA annually vs. every other

year 1.3/2.6 vs. 1.8/3.5 ($P < 0.0001$), respectively, and trees pruned annually vs. every other year 0.8/1.6 vs. 2.2/4.4 ($P < 0.0001$), respectively. However, in 2021, despite potential poorer recovery of return bloom due to treatment with NAA or pruning annually, including 2020, the February 2021 cytokinin-PGR treatment resulted in greater bloom estimates as both the average or sum of the east and west bloom estimates compared to their counterparts not treated with the cytokinin (Table 1). Trees receiving the cytokinin-PGR treatment also had significantly greater total yields compared to their counterparts in the NAA or pruning treatments not treated with the cytokinin-PGR and OFF-crop control trees and equal to the ON-crop control trees. There were no significant treatment effects on yields of commercially valuable size fruit of packing carton sizes medium+large but trees treated with the cytokinin-PGR tended to have greater yields of medium+large size fruit equal to that of the ON-crop control trees (Table 1). Whereas these preliminary results are promising, the cytokinin treatment must be confirmed to be effective over consecutive years and that the trees do not compensate for increased yield one year with reduced yield the next year. Both the average bloom estimate per tree and sum of the bloom estimate per tree were significantly effective in predicting total yield and yield of commercially valuable size fruit (medium+large), with $r = 0.83$ ($P < 0.0001$) for total yield and $r = 0.80$ ($P < 0.0001$) for yield of medium+large fruit.

Treatment effects on yield in 2021.

We also made visual estimates of yield on the east and west side of the trees just prior to harvest, with a calculated average per tree and sum of the east and west sides per tree (Data not shown). As expected, there is a significant correlation between the average (or sum) of estimated bloom per tree and the average (or sum) of estimated yield per tree in 2021 ($r = 0.68$, $P < 0.0001$). This relationship has proven strong over the years of research. For the combined pool of data for 2019, 2020 and 2021, the correlation coefficient is $r = 0.75$ ($P < 0.0001$). In 2021, both average estimated bloom per tree and average estimated yield per tree were strongly correlated with total yield as kg per tree at harvest ($r = 0.83$, $P < 0.0001$ and $r = 0.88$, $P < 0.0001$, respectively) and yield of medium+large size fruit at harvest ($r = 0.80$, $P < 0.0001$ and $r = 0.79$, $P < 0.0001$, respectively). Interestingly, when average or sum of the bloom estimates for the two sides of the tree and average or sum of the yield estimates for both sides of the tree were used across the past 3 years of the research (2019, 2020 and 2021), bloom estimate (average or sum) was the better predictor vs. yield estimate (average or sum) for total yield ($r = 0.79$, $P < 0.0001$ vs. $r = 0.55$, $P < 0.0001$, respectively) and yield of medium+large size fruit ($r = 0.60$, $P < 0.0001$ vs. $r = 0.42$, $P < 0.0002$, respectively).

As part of our research, we have been investigating the potential utility of bloom estimates to guide the decision to apply NAA or to prune in a given year. This necessitated that we investigate the relationship between total yield and yield of commercially valuable medium and large size fruit to determine at what total yield (kg/tree) the greatest yield of medium and large size fruit is obtained. Using our data set of more than 500 tree-years, median yield was 110 kg/tree for this data set, indicating 50% of the trees in the data set produced ≥ 110 kg/tree but 50% of the trees in the data set produced less. Lower yields are associated with more fruit in larger fruit size categories, i.e., fruit size greater than or equal to extra-large size fruit at harvest. As total yield increases the yield of medium size fruit continues to increase up to total yields of 150 to 160 kg/tree; yield of large size fruit is stable at 22 to 25 kg/tree for total yields > 110 to 150 kg/tree. However, at total yields > 120 kg/tree, there is significant increase in the yield small and petite size fruit, making the yield of fruit in these two size categories approximately 50% off total yield. On average in this data set, maximum yields of medium+large size fruit are between 43-54 kg/tree at total yields between 90-110 kg/tree and 54-56 kg/tree at 110-120 kg/tree. Since total yield > 120 kg/tree increases the yield of small and petite size fruit of limited commercial value to approximately 50% of total yield and would contribute to alternate bearing, they should be avoided. Total yields that stabilize yield annually may benefit from a cytokinin-PGR treatment to increase the yield of medium+large size fruit. **Note:** that low yielding trees

produce low yields of fruit in all size categories. This is a limited set of data. We will continue to investigate the relationship between total yield, yield of commercially valuable size fruit (medium+large) and the severity of alternate bearing to identify the target total yield that maximizes return bloom, yield of medium+large size fruit and net profit. Please advise us if you wish for us to focus on different or additional fruit size categories.

Our result suggest 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. We still need to identify an upper threshold value for the bloom estimate that indicates that crop removal treatments need to be carried out.

2) Treatment effects on fruit size and quality.

In a given year, the number of black fruit at harvest is inversely related to total yield. OFF-crop trees had significantly more black and partially black fruit compared to fruit from trees in all other treatments, but the total was only 16.5% of the fruit on the tree in 2021, i.e., the OFF-crop trees had 83.5% green fruit. Trees in all other treatments, except trees pruned every other year (treatment 3), had 95.5% to 99.2% green fruit which was significantly more than the OFF-crop control trees. Trees in treatment 3 had 90.5% green fruit, which was equal to and not statistically different from that of all other treatments. Treatment 3 had a low yield equal to that of the OFF-crop control trees.

3) Treatment effects on yield 2017-2021.

In all cases, treatments were first applied to ON-crop trees. The initial ON-crop control trees selected in 2017 (treatment 4) have continued to produce alternating ON and OFF crops. These trees are ON-crop trees in 2021. The trees initially selected as the OFF-crop control trees in 2017 subsequently produced three back-to-back ON crops followed by an OFF-crop in 2021 (Table 2). These differences demonstrate the need for a tool, such as bloom estimate, to indicate when trees should and should not have the crop thinned. 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). For total yields from 2017 through 2021, the average ABI for treated trees is 0.47 to 0.68, significantly lower than the average ABI of 0.89 for the original ON-crop control trees (treatment 4), with the exception that trees treated with NAA on one side of the tree and then other side annually (treatment 5) have an average ABI intermediate to and not significantly different from the ON-crop control trees and the trees in all other treatments. Since 2019, the treatments have been stabilizing the yield of commercially valuable size fruit, though there is still a further need to maximize the yield of medium+large size fruit (Table 2), while maintaining a low ABI.

Goal for next year.

Taken together, the results of this research provide evidence that: (1) the NAA and pruning strategies used in our research give similar results, in most years; (2) the strategy of applying NAA or pruning treatments starting in an ON-crop year with reapplication every other year is a better strategy than annual treatment for evening out yields in an alternate bearing orchard; (3) this approach improves yield of commercially valuable size fruit and reduces the yield of black fruit at harvest; and (4) application of the cytokinin-PGR treatment to sets of NAA-treated or pruned trees showed promise by increasing flowering (bloom

estimates), total yield and yield of medium+large size fruit (not significantly) relative to their counterpart trees not treated with the cytokinin PGR and equal to that of ON-crop trees in 2021.

The goal of next year's research is to stabilize total yield at the optimal yield that results in maximum yield of medium+large size fruit on an annual basis. To do this we will optimize the NAA and pruning strategies applied to one side of the tree and then the other side of the tree every other year alone and in combination with the cytokinin-PGR treatment to determine the efficacy of the cytokinin-PGR treatment to maximize yield of commercially valuable size fruit annually. In addition, we will test the flexible application of the NAA and pruning strategies (not used when the side of the tree to be left untreated has a bloom estimate less than 2.0). Additionally, we will develop the use of the alternate bearing index for total yield and yield of medium+large size fruit as a tool (alone or combined with bloom estimate) to determine whether alternate bearing has been mitigated and fruit thinning treatments can be ceased until alternate bearing is initiated again. **Note** that we will use Liqui-Stik[®] NAA (Loveland Industries) in 2022 as requested. We will not be testing Mandolin[®] NAA (AMVAC Corp.) as planned, because AMVAC recently decided not to register Mandolin for use on olives in the near term. Our overall goal is to optimize total yield at a level that results in maximum yield of commercially valuable size fruit with minimum variation from year to year, such that the sum of two annual yields of commercially valuable size fruit is greater than the sum of the ON/OFF yields of an alternate bearing cycle.

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Table 1. Effect of crop load and two fruit thinning treatments, foliar application of the PGR NAA at full bloom (May 6) and pruning 28 days after full bloom (May 31) in 2020 to one side of the tree and then the other annually or every other year on the intensity of the 2021 bloom of ‘Manzanillo’ olive trees (estimated prior to full bloom on May 4, 2021, using the scale in footnote “z”) and total yield and yield of medium+large fruit as kg/tree. Starting in 2021, NAA and pruning treatments were applied to every other side every other year; thus, NAA and pruning were not applied in 2021 and will be applied in 2022 to the side of the tree not treated in 2020. The cytokinin PGR was applied to the full canopy in February 2021 prior to bud break to increase flowering and was thus applied before the bloom estimate) and will be applied again in July 2021 prior to summer vegetative shoot growth and again in February 2022.

2020 ^y		2021		2021 Bloom estimates (Before 2021 treatment)		2021	2021
Completed	Treatments To be done	West side of tree	East side of tree	Average per tree	Sum per tree	yield kg/tree	Med+Lar kg/tree
1 ON-crop control	OFF-crop control	0.9 c ^x	1.3 c	1.1 c	2.2 c	48.1 c	33.5 a
2 NAA – West side of tree @ full bloom (May 6) (every other year)	NAA – No treatment	2.2 b	2.4 ab	2.3 ab	4.5 ab	69.9 bc	42.0 a
3 Pruned - West side of tree @ 28 days after full bloom (June 2) (every other year)	Pruned – No treatment	1.8 b	1.5 bc	1.6 bc	3.3 bc	49.0 c	33.5 a
4 OFF-crop control	ON-crop control	2.9 a	2.9 a	2.9 a	5.8 a	115.3 a	47.8 a
5 NAA - East side @ full bloom (May 6)	NAA – No treatment, Cytokinin PGR applied Feb+July to full canopy	3.0 a	2.7 a	2.8 a	5.6 a	107.9 a	48.5 a
6 Pruned - East side @ 28 days after full bloom (June 2) (annually)	Pruned – No treatment Cytokinin PGR applied Feb+July to full canopy	2.2 b	1.8 bc	2.0 b	3.9 b	85.0 ab	45.0 a
<i>P</i> -value		0.0018	< 0.0001	< 0.0001	< 0.0001	0.0004	0.3238

^zBloom was evaluated on the following scale: 0, no inflorescence; 1, low floral intensity; 2, medium floral intensity; and 3, high floral intensity.

^yAll 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.

^xMean 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 (May 30, 2018, May 31, 2019, and June 2, 2020) to one side of ‘Manzanillo’ olive trees and then the other side annually or every other year on annual total yield and yield of commercially valuable size fruit of packing carton size medium+large. Starting in 2021, NAA and pruning treatments were applied to every other side every other year; thus, NAA and pruning were not applied in 2021 and will be applied in 2022. The cytokinin PGR was applied to the full canopy in February 2021 prior to bud break to increase flowering and yield and again in July 2021 prior to summer vegetative shoot growth to increase summer vegetative shoot growth, fruit size and return bloom in 2022.

2018 ^z	2019	2020	2021	2018		2019		2020		2021	
Treatment ^z				Yield (kg/tree)	Fruit size (g/fruit)	Yield (kg/tree)	Med+Lar (kg/tree)	Yield (kg/tree)	Med+Lar (kg/tree)	Yield (kg/tree)	Med+Lar (kg/tree)
1 ON-crop Control	OFF-crop control	ON-crop control	OFF-crop control	121.5 a ^y	4.4 d	134.6 d	48.0 a	79.3 a	33.9 a	48.1 c	33.5 a
2 NAA-East side of tree	No treatment	NAA-West side of tree	NAA – No treatment	83.6 b	4.9 c	156.1 bcd	35.7 abc	28.5 b	18.3 abc	69.9 bc	42.0 a
3 Pruned-East side of tree	No treatment	Pruned-West side of tree	Pruned – No treatment	100.5 ab	4.3 d	141.6 cd	43.7 ab	59.6 a	28.7 ab	49.0 c	33.5 a
4 OFF-crop control	ON-crop control	OFF-crop control	ON-crop control	26.8 c	6.1 a	211.4 a	19.2 c	9.7 b	7.0 c	115.3 a	47.8 a
5 NAA-East side of tree	NAA-West side of tree	NAA-East side of tree	NAA – No treatment, Cytokinin PGR applied Feb+July to full canopy	39.6 c	5.5 b	179.8 b	55.1 a	24.2 b	16.4 bc	107.9 a	48.5 a
6 Pruned-East side of tree	Pruned-West side of tree	Pruned-East side of tree	Pruned – No treatment Cytokinin PGR applied Feb+July to full canopy	47.5 c	5.6 ab	161.4 bc	22.5 bc	20.4 b	15.5 bc	85.0 ab	45.0 a
<i>P</i> -value				<0.0001	<0.0001	<0.0001	0.0138	<0.0001	0.0257	0.0004	0.3238

^z All trees were topped on July 7, 2017, May 30, 2018, May 31, 2019 and June 1, 2020. All trees were skirted on July 1, 2020.

^y Mean values within a vertical column followed by different letters are significantly different at the specified *P* level by Fisher’s Protected LSD.

Institution/Organization: University California, Davis

Department/Division: Plant Sciences

Project Year: 2020- 2021

Anticipated Duration of Project (yrs.): 4+

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Precise water management strategies for table olive orchards in California

Report 2021 season

Methods

In March 2020, we selected an experimental orchard, located in Orland. The trees were approximately 15 years old Manzanillos planted at a density of 180 trees per acre.

The ET tower was installed on May 19th 2021. Distribution uniformity of the irrigation systems was evaluated in April; it was 89.37%. A flow meter was installed in July to monitor applied water and irrigation frequency in the full irrigated area (where the ET station is installed) but, due to technical problems, we were not able to collect this season's data on applied irrigation.

Four experimental blocks were selected and flagged to apply in a randomized block design four different regulated deficit irrigation treatments; each block was three consecutive rows, 24 trees long with the blocks randomized along the orchard as shown in Fig 1. The ET tower was placed in the middle of the fully irrigated block and measured an area roughly represented in Fig 1. with a dotted circle. All measurements were taken on three trees selected in the central row of the three row blocks, with the other two rows as borders to ensure efficacy of the irrigation treatment.

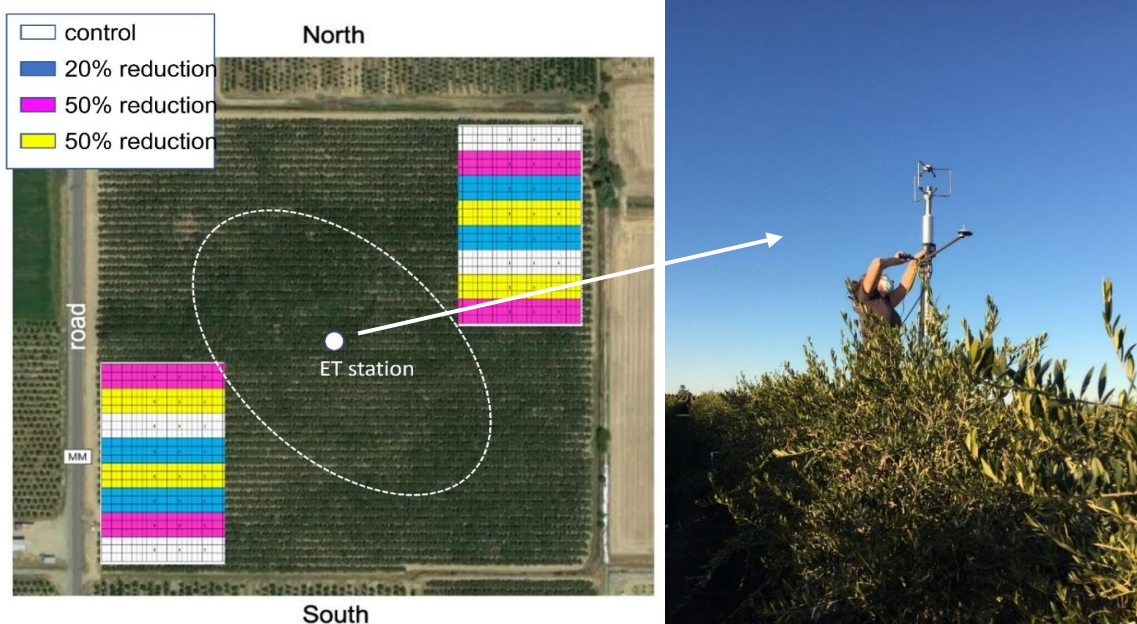


Figure 1. Map of the experimental design with the replication of the different blocks, the location of the ET station, and an example of the measurement area of the station (dashed circle); the legend indicates

the correspondence between the map blocks/colors and deficit irrigation treatments. On the left: sensors' setup installed above canopy to measure ET.

Soil moisture sensors (Watermark Irrrometers) were installed at 18, 36 and 48 in in one location per each treatment, in early May . Getting a good contact between soil sensors and soil was very challenging due to the very coarse soil structure. Sensor readings were affected by this poor contact between sensor and soil. We plan to reinstall them in 2022, although coarse soils are challenging to be monitored with the soil sensors.

At pit-hardening (July) we implemented the deficit irrigation treatments, with 3 treatments: (1) a control (no changes to the irrigation system following usual grower's practice), (2) water application reduced by 20% and (3) water applications reduced by 50% in two treatments. Based on our initial results, we plan to manage differently two 50% treatment blocks next year in the period pre- pit hardening, one will be based on SWP and one based on ET.

On 3/31/21 a drone flight was performed to characterize the homogeneity of the orchard in terms of temperature (Fig. 2, left), where the green colors are cooler temperatures driven by transpiration of the plants, and the red colors in parts of the orchard mean higher plant temperature under reduced transpiration, and NDVI (Fig. 2 right), where the yellows represent canopy covered surface. The same images show a strong difference between the South-West and the North-East side of the orchard, while the area where ET is measured seems more homogeneous (Fig. 2) which ensures that our measurements are representative of the fully irrigated orchard.

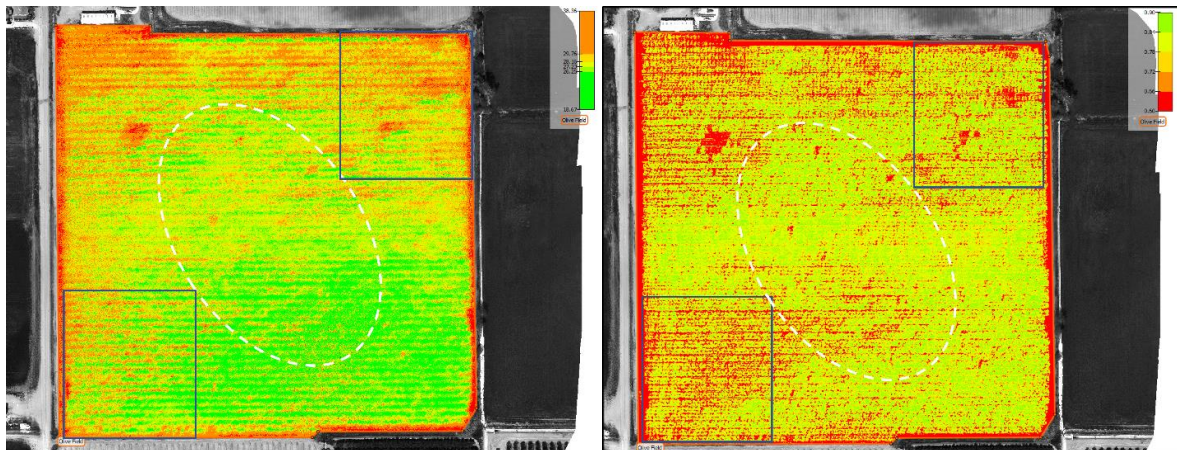


Figure 2. *Thermal and multispectral images of the olive orchard showing difference in canopy cover and temperature within the whole orchard and experimental blocks. The blue squares roughly represent the location of the deficit irrigation treatments areas and the dashed circle is a rough estimate of the measuring area for the ET station.*

On the three selected trees per block (12 trees per treatment), starting in March, we measured midday stem water potential (SWP) weekly, and vegetative growth on one selected branch per tree. Only in the control treatment we also characterized biweekly phenological stages of development and fruit biometric parameters (fresh and dry weight, longitudinal and transversal diameter, pit breaking force and color).

To characterize the impact of deficit irrigation on olive quality, at harvest longitudinal and transversal diameter were measured in the lab on 15 olives per block (60 olives per treatment), and a 20 pound bag per block was delivered to the Musco facility for standard commercial grading on October 5th. Bruising sensitivity was also measured, and the cuticles were isolated for cuticular wax quantification. Unfortunately, excessive pre harvest water stress associated with the need to reduce irrigation to facilitate harvesting, temporarily resulted in fruit dehydration and required immediate irrigation. This affected our capability to collect yield data. However, we consider fruit quality parameters that were collected representative of the objectives of this study and will give us valuable results for subsequent experimental years.

Results

The olive actual evapotranspiration (ET_a, Fig. 3) increased from 0.15 inches per day at the end of May to 0.20 in/day at the beginning of July. From mid-July ET decreased constantly to values of 0.1/0.15 in/day observed until the first half of August and to values of 0.05/0.15 in/day observed in late August and September. This decrease was also observed in the reference ET from the closest CIMIS station. As expected, this shows that the drivers for ET were stronger between May and the end of July than they were between August and October.

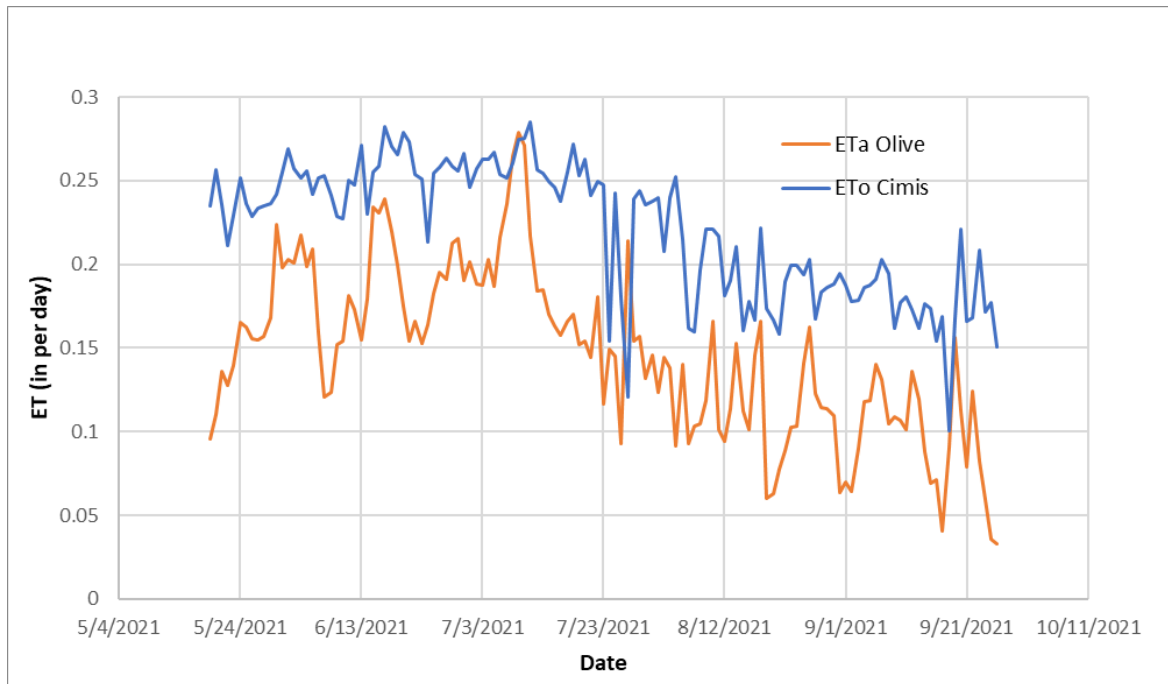


Figure 3. Olive Actual evapotranspiration, ET_a, (inches per day) in comparison to the reference ET_o from the close CIMIS station

The crop coefficient (Fig. 4) increased from 0.6 (late May) to almost 0.8 (beginning of July), then decreased to 0.55 in mid-July, and kept constant through the rest of the season. We averaged the daily values into biweekly means to avoid the variability in crop coefficient that are driven by irrigation events.

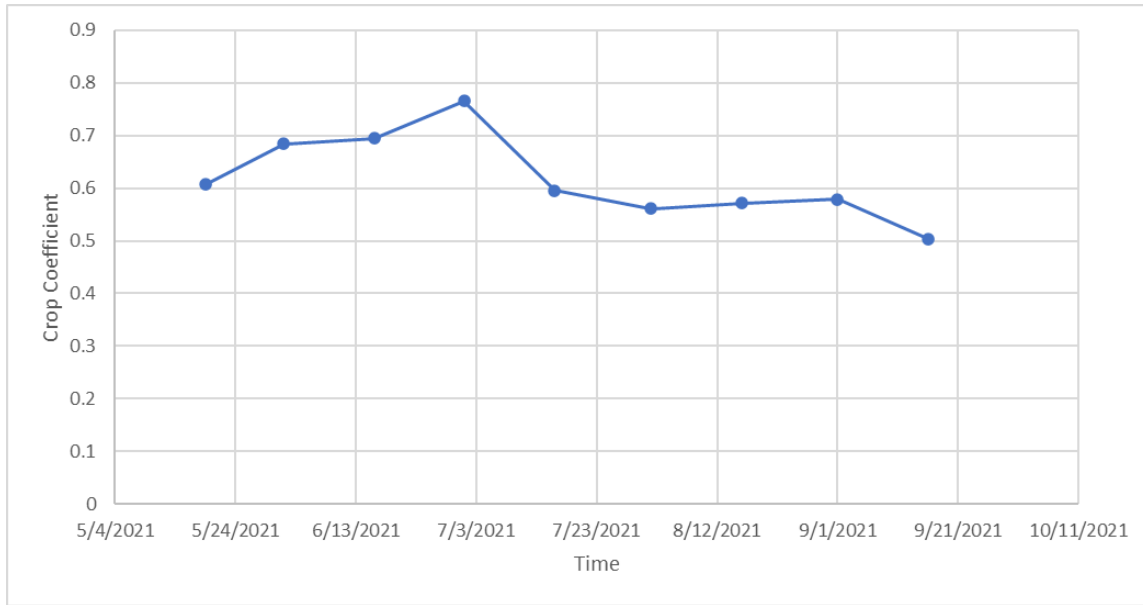


Figure 4. Biweekly olive crop coefficient measured at the experimental site

Stem water potential (SWP) of the control treatment (no deficit, standard grower practice) decreased from March, when it was -1 MPa, until the beginning of August, when it reached -2.2 MPa (Fig. 5). At the same time, the SWP baseline decreased from -0.7 to -1.3 MPa, indicating that the SWP decrease in control trees was probably associated with an overall increase in vapor pressure deficit (hottest/driest air). Because vapor pressure deficit is important driver for evapotranspiration, increase in ET_a and K_c values was simultaneously observed. The control SWP was 0.3 to 0.9 MPa lower than the baseline, indicating mild stress.

The baseline represents the highest SWP achievable for that day-specific weather conditions - maximum level of tree hydration when soil moisture is not a limiting factor. However, the baseline gives information about the maximum level of hydration an olive tree can reach, which is not necessarily the optimal water status from a horticultural/commercial point of view.

The control SWP values stayed constant from the beginning of August until the end of September, with values ranging between -1.6 to -1.8 MPa while the SWP baseline was between -0.9 and -1.2 MPa. At the end of September, the control SWP decreased sharply from -1.5 to -3 MPa within a two week period. This was associated with the need to reduce irrigation for harvest. Interestingly, the baseline increased during that time, suggesting a reduced water requirement due to weather conditions. The lower values of baseline SWP relative to control SWP suggest that it may be possible to improve tree water status with higher irrigation volumes.

The reduced irrigations decreased SWP by ~ 0.2 , 0.4 and 0.8 MPa relative to the control in the 20% and the two 50% water reduction treatments, respectively (Fig. 5). The difference between the two 50% irrigation treatments is likely to be associated with the heterogeneity of the orchard, despite the randomization of the blocks should have smoothed this difference out.

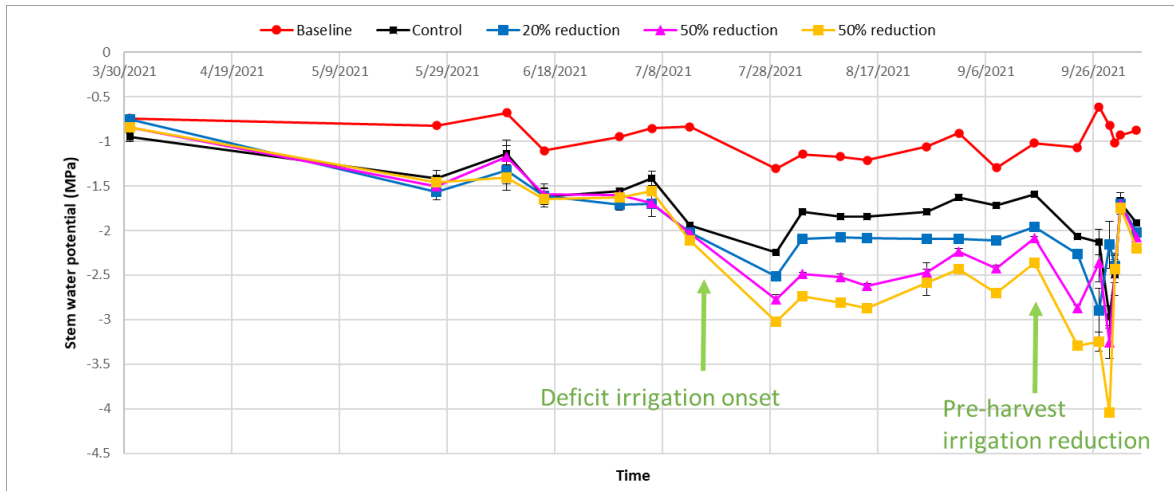


Figure 5. Seasonal variation of the stem water potential (MPa) of the control treatment in comparison to the baseline (Shackel et al., under revision), and the three deficit irrigation treatments. The baseline represents the potential SWP values of fully hydrated olive trees from data on literature.

Details of tree water status represented as SWP in the week before harvest, when irrigation was withheld, and later, when trees were again irrigated, are reported in Fig. 6 to highlight tree water status recovering. The SWP dropped in all treatments and the gap between the control and the most stressed treatment (the 50% yellow treatment) increased to -1.1 MPa. The SWP of the 20% reduction treatment was similar to the control, and the one of the 50% reduction (pink) was 0.4 MPa lower than the control. The tree water status recovered fully within one day of reinstating irrigation. No differences were observed among treatments from the 1st of October.

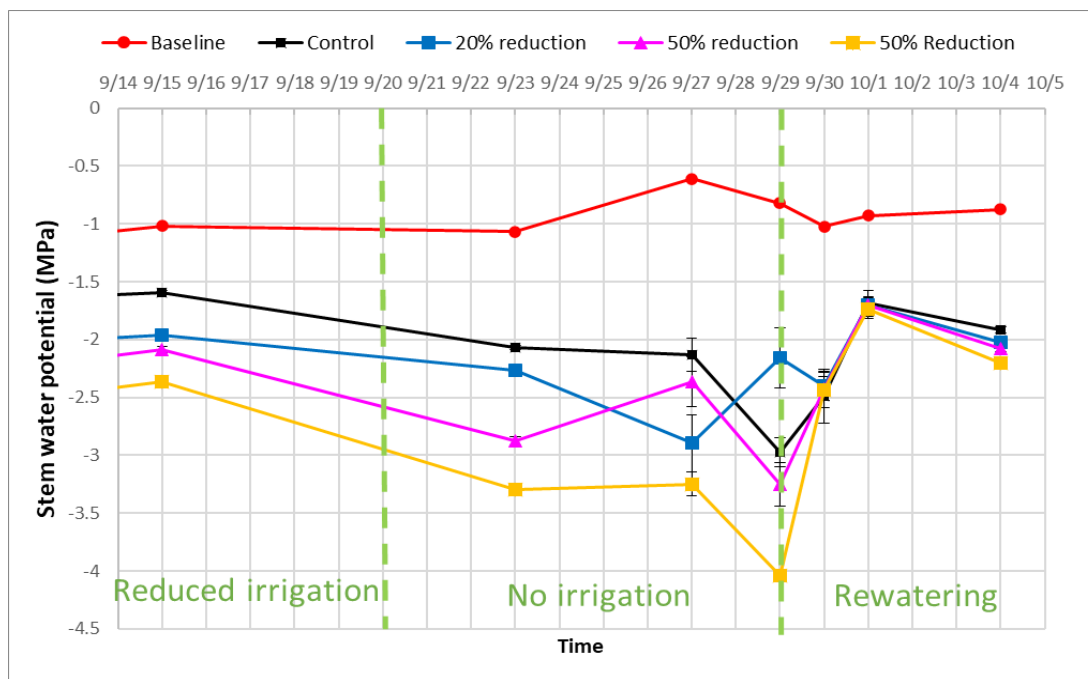


Figure 6. Detail of the stem water potential (MPa) drop and recovery for the different treatments associated with pre-harvest irrigation reduction. Baseline still corresponds to hypothetical values of fully irrigated trees for that day-specific environmental conditions..

Vegetative growth rate expressed as cm of new growth per day (Fig. 7), was relatively high in May, decreased strongly in June, and reached zero values in July and August. At the beginning of September, the vegetative growth resumed with the most stressed treatment (50% yellow) having a lower growth rate than the other treatments.

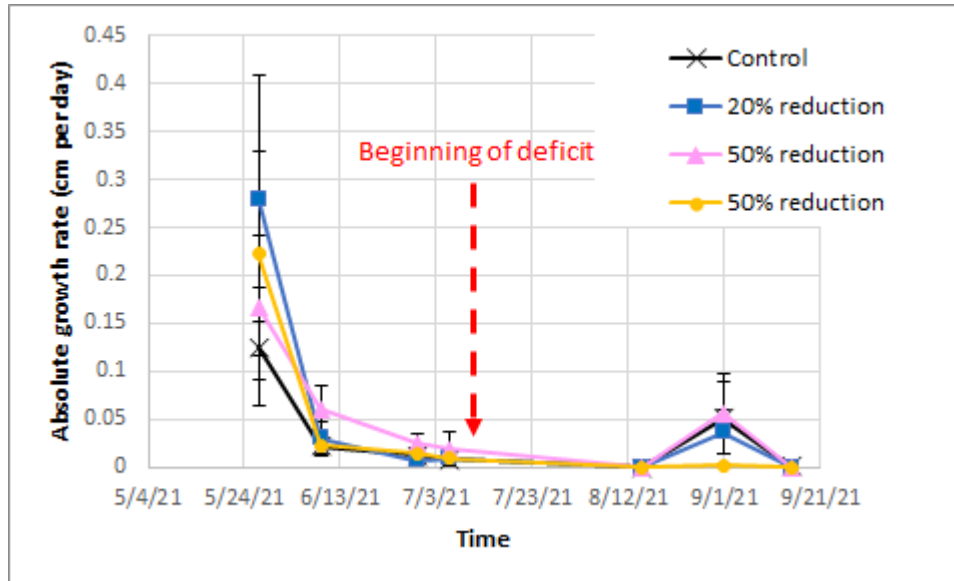


Figure 7 Vegetative growth rate expressed as cm of new growth per day for the different irrigation treatments through the season. The red arrow represents the beginning of the deficit irrigation treatments.

Fruit dimension, expressed as longitudinal and transversal size in the control treatment, increased at the beginning of the season through mid-August when it reached a plateau that persisted until harvest (Fig. 8). Fruit fresh and dry weight and pit hardening were also measured. These data were collected only in the control treatment to characterize fruit phenological development.

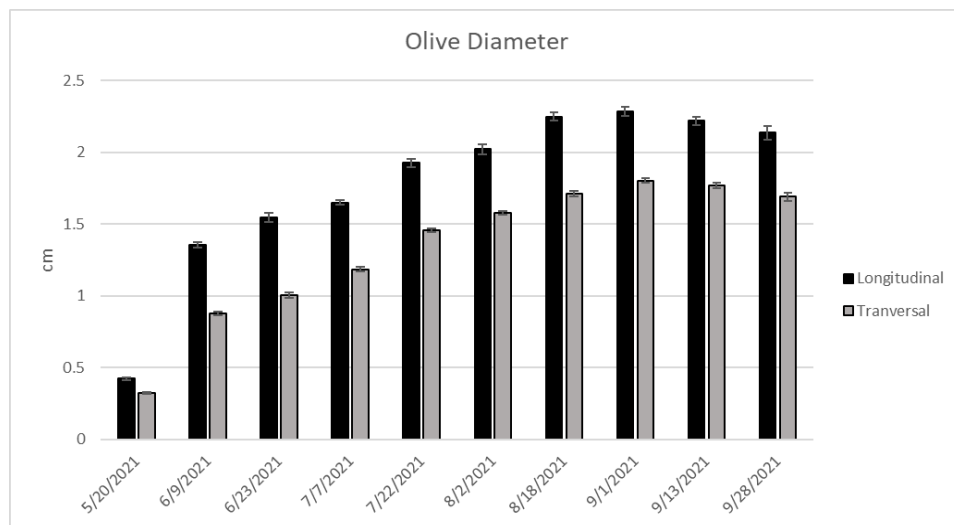


Figure 8. Longitudinal and transversal dimensions of olive fruits in the control treatment.

In summary, during this first experimental season produced a dataset of tree water use and tree water status of a typical table olive orchard in California. Based on a comparison with the reference SWP baseline developed by other past studies, we hypothesize that a higher level of hydration could be achieved in the control treatment. This is attractive and interesting to explore further in the coming years as this could also increase the crop coefficient. It should be noted that water availability was relatively low in 2021, due to the very dry winter and summer. We hope to compare this year's findings with different hydrological conditions in the future for more robust conclusions. In the first year, we have managed to establish and test the experimental field monitoring system which required significant time. We anticipate that the data gathered this year will be valuable piece of the information in the potential next experimental years.

CALIFORNIA OLIVE COMMITTEE
COC RESEARCH INTERIM REPORT

Workgroup/Department: School of Engineering – Mechanical Engineering

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

Project Title: Combining trunk 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)

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

Commodity: _____ Relevant AES/CE Project No.:

Year Initiated: 2021_Anticipated Duration of Project: one year

Objectives:

- Study effect of a larger canopy shaker and trunk shaker on old and large olive trees.
- Find the best shaking parameters (frequency, amplitude, duration).
- To disseminate the integrated knowledge gained through this research.

Experimental Procedures:

To achieve the objectives of the proposed project, the following specific tasks were done:

Task 1- Design and construct a very larger side-mounted canopy shaking head that can be attached to a mini-excavator and can accommodate shaking the canopy of larger trees (Fig-1).

Task 2- Conducted a field test at Deleonardis Ranch to evaluate performance of the newly designed canopy shaker and use the data to estimate the total yield.

Progress Update:

The new canopy shaker was built in Ehsani's Lab (Fig. 2). The new canopy shaker head has a rectangular shape with height of 8ft and width of 10ft. The shaker head has a total of 37 mounted Teflon rods. These plastic rods are the contact point between the canopy shaker and the tree. Each rod has 1in diameter and 26in length. A branch shaker was built instead of a trunk shaker as it would be more versatile and compatible to irregular trunk shapes.

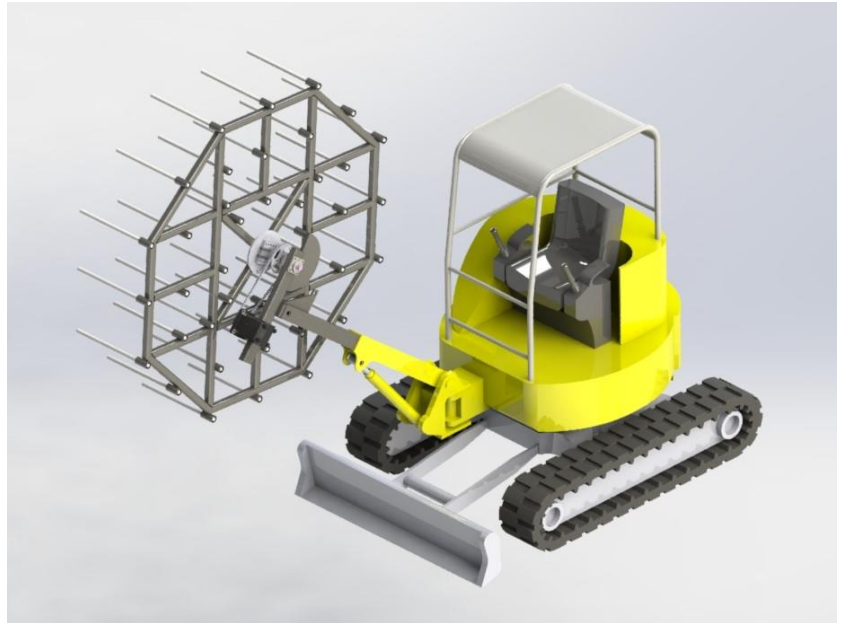


Figure 1. Proposed shaker design that includes a side-mounted canopy shaker.



Figure 2. Newly designed canopy shaker built for old large olive trees in California.

Shaker head was installed on a Bobcat 337. Figure 3 shows the off-center mechanism used to generate circular oscillatory motion. The canopy shaker was set to a 2" off-center distance, generating an oscillation with a 4" amplitude.

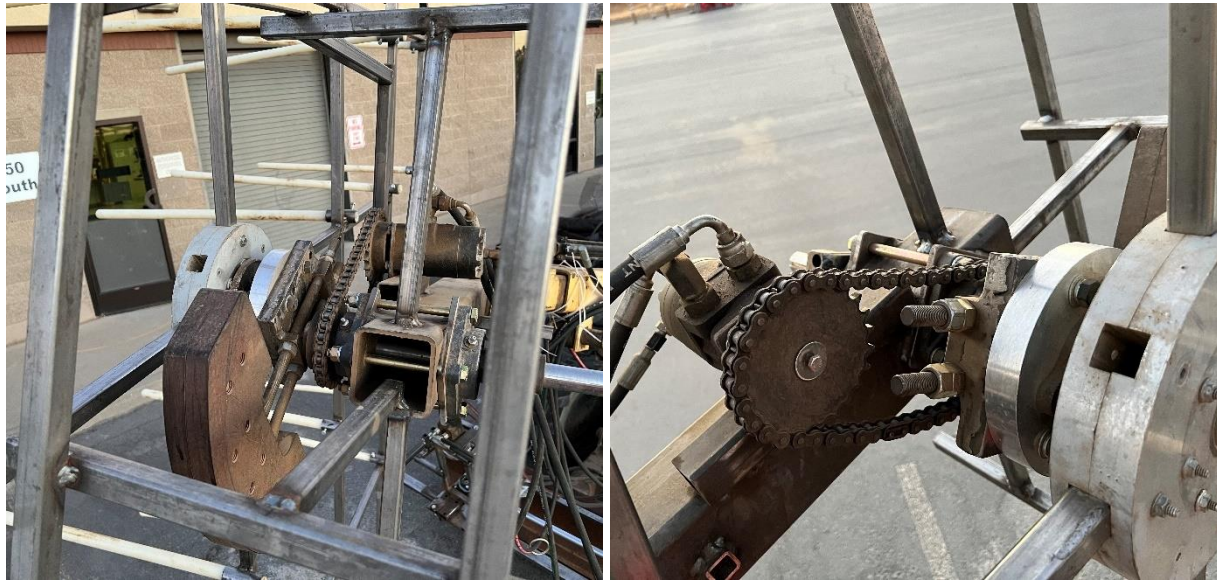


Figure 3. The internal mechanism used to generate circular oscillation movement in the canopy shaker

Experimental Procedure and Preliminary Results

This shaker machine was tested in the Deleonardis Ranch on September 23rd, 2021. The 30 year old, 20 x 26 spaced sample trees were topped at 12 and 14 feet in May 2021. Four trees were randomly selected from each height category for this experiment. 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.

Table 1 shows the weight of the fruits harvested by the canopy shaker and what was harvested by the gleaning crew. Harvest efficiency was calculated using the equation below.

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

Table 1. Harvest fruit data from each tree.

Tree	Topped height (ft)	Mechanically harvested fruits (lb.)	Manually harvested fruits (lb.)	Total weight	Harvest Efficiency
1	12	53.4	118.4	171.8	31%
2	12	63.6	103.9	167.5	38%
3	12	53.3	104	157.3	34%
4	12	41.2	131	172.2	24%
5	14	83.6	115.4	199	42%
6	14	61.2	95.3	156.5	39%
7	14	60.1	76.3	136.4	44%
8	14	50.1	100.6	150.7	33%

Observation

The shaking head was able to remove most of the fruits where it contacted the canopy. The low harvest efficiency was mostly due to lack of adjustability of the shaking head itself which will be addressed in future iterations. The branch shaker used in the experiment needed some reinforcement to increase its reliability.

Conclusion and Future work

A modified canopy shaker design was conceptualized and built based on field observation (Figure). The new side-mounted canopy shaker is designed for bigger older olive trees which have not been trained for the mechanical shaker. The shaker attachment will allow the machine to go through orchard rows and shake every single tree at the required height.

The future design needs to have a smaller shaker head with more degrees of freedom for better adjustment. A shaker head with two or three degrees of freedom can be used to increase harvest efficiency. In a future design the shaking rods need to be padded to reduce damage during the harvest. Data for the amount of damage to the fruits in the current experiment will be presented in the final report.

INTERIM REPORT –10/2021
California Olive Committee (COC) and California Olive Oil Committee (COOC)

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 and results –

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

Laboratory direct exposure assays were repeated with nisin, ϵ -poly-L-lysine, capric/caprylic acid (Dart), and a formulation of essential oils (ET-91) inhibited growth of *Psv* at by 5-log at selected rates and exposure times of 30 min. The activity of these food preservatives was enhanced in mixtures with EDTA. Several greenhouse and field efficacy studies were conducted using new bactericides by themselves or in selected mixtures, and efficacy was compared to copper, kasugamycin (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. Kasumin mixed with dodine (i.e., Syllit) was highly effective and outperformed Kasumin-copper. Copper-dodine also outperformed copper alone. Oxytetracycline (Mycoshield, FireLine) mixed with Dart was highly effective in most trials but the antibiotic was consistently highly effective when mixed with copper or dodine for protecting infection of lateral wounds and leaf scars. Mixtures of nisin, ϵ -poly-L-lysine, and Dart were highly efficacious on both types of wounds. We are currently working with a registrant interested in the food preservatives nisin and ϵ -poly-L-lysine. A commercial formulation of the active ingredients was provided with UV-protection and adjuvants to improve residual activity, and tests are ongoing. Therefore, we will continue our efforts in making oxytetracycline and the antibacterial food preservatives that all have high in vitro toxicity more consistently effective. Dodine will be an important mixture component with copper, kasugamycin, and oxytetracycline. Additional spring trials will be evaluated in early October 2021.

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, but now it has changed to winter 2022 along with the walnut petition. 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 2021 with a PRIA date of November 2022. Syllit is being federally registered on olive based on IR-4's submission to EPA through the Chemistry Science Advisory Council (ChemSAC) program in early 2021, and olive is being added to the label. This label amendment was submitted by IR-4 on July 2, 2021. The current PRIA date is November 2022. UPL also requested a concurrent review of kasugamycin and dodine in the state of California this summer.

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 and results -

1. Evaluate the performance of new and older fungicides in field trials and application timing of selected treatments.

Ziram (Dithiocarbamate - FRAC Code or FC M3), Ph-D (polyoxin-D - FC 19), Syllit (dodine-FC U12), Abound (azoxystrobin-FC 11), the pre-mixtures Inspire Super (difenoconazole-cyprodonil- FC 3/9) and Quadris Top (difenoconazole/azoxystrobin - FC 3/11), and tank mixtures of Ph-D and Syllit, as well as ziram and copper were compared to copper as a standard treatment in reducing olive leaf spot in three field trials in Glenn, Sutter, and Yolo Co. Treatments were applied in the fall (Nov. 2020) and were evaluated in April 2021 for peacock spot. All treatments significantly reduced the disease from the control; Inspire Super, Ph-D, Quadris Top, Syllit, and the Syllit-Ph-D tank mixture were

the most effective in all three trials. Polyoxin-D (Ph-D) was also highly effective in our 2019, 2020, and 2021 trials, and UPL has agreed to add olive to the fungicide label. This research is ongoing.

- 2. Evaluate application timing and adjuvants of selected treatments.** Timing studies were not done due to low rainfall in the winter of 2021.
- 3. 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. Also in low rainfall environments, sporulation is low. Spore germination assays in the presence of fungicides are ongoing.
- 4. IR-4 GLP Studies (Registration update).** In 2021, 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 2020-21. 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 have assisted in developing protocols for field studies in 2021-22. Because polyoxin-D (Ph-D) is a biopesticide, it is exempt from tolerance and thus, no residue studies are needed. UPL is amending the label to include olives. Dodine (Syllit) has European tolerances, and IR-4 petitioned EPA through the ChemSAC process to register the fungicide on olive using existing residue data. We prepared the request and justified the need. This label amendment was submitted by IR-4 on July 2, 2021. The current PRIA due date is November 2022. In the summer of 2021, the registrant has submitted for a concurrent review with the state of California. Syllit is currently registered on pome fruit and almond in California.

Interim Report

Characterization of olive fruit abscission zone in response to ethylene applications and as a function of accumulated heat unit

Authors: Minmin Wang, Shuxiao Zhang, Georgia Drakakaki

Cooperative personnel: Louise Ferguson, Emily Santos, Judy Jernstedt

Introduction

Mechanical harvesting of table olives requires a fine regulation of fruit abscission, while it does not cause excessive leaf loss and thus ensures 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 and its combinations 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 force between the olive fruit and stem during ripening is of high economic value in the olive industry. Utilization of mechanical harvesting is a current trend in California table olive industry, thus the efficiency of mechanical harvesting has received attention in optimizing tree shape management for trunk shaking in combination with chemical applications, in order to reduce the necessary 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 a small amount of ethylene treatment does not trigger the positive feedback of the fruit ripening process (Rugini et al., 1982). Multiple fruit loosening agents have been tested in olive trees (Burns et al., 2008), and many of them have been successful in citrus studies as well, 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 (Burns et al., 2008). Tested ethylene-forming compounds require an application at 1000 mg/L to effectively reduce the fruit removal force by 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 a solution containing 0.2% ethrel together with 0.3% ascorbate or butyrate. Anatomical studies indicated that the antioxidants counteract the ROS formation at the leaf peduncles, protecting leaves from abscission triggered by ethylene. Transcriptome analysis of ethephon treated and untreated abscission zone 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 spray of this chemical combination 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. Studies in lignin deposition at the abscission zones of leaves and fruits in olives, showed the deposition 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 to pectin 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.

Material and Methods

Sample collection and ethephon treatment

May 12th, 2021 was set as week 0 for the fruit development, as the end of anthesis. Six untreated fruit branches were collected biweekly through pre-harvest season, starting from 4-week post-anthesis. Samples of potential abscission zones indicated in **Figure 1B** were fixed by 4% paraformaldehyde in microtubule stabilizing buffer (80 mM PIPES, 1 mM magnesium chloride, 2 mM EGTA, pH 6.9) or phosphate buffered saline (PBS, 137 mM sodium chloride, 2.7 mM potassium chloride, 10 mM sodium phosphate dibasic, 1.8 mM potassium phosphate monobasic, pH 7.4) with 0.1% tween-20, and after a PBS wash were kept at 4 °C for further structural analysis. Similarly, separate replicates were snap-frozen in liquid nitrogen until further analysis.

Ethephon and water control solution (control) were applied to trees in the olive orchard at three different dates (Yellow, September 10th; Pink, September 13th; Green, September 16th) by Ferguson Group (**Figure 2A**), corresponding to three different accumulated heat units (ATU). Trees in white rectangular were sprayed by water control. In coordination with Ferguson Group, two biological replicates of fruit branches were collected from each treatment group on the day of harvest (September 22nd, 2021), one hour before the mechanical harvest started.

Microscopy based analyses

Fixed samples described above are washed by distilled water and embedded in 5% agarose in 2 cm molds for sectioning on a vibratome. Thickness of sections was set at 200 µM for all samples. Sections were incubated in 0.1% toluidine-O blue solution for 5 s and washed by distilled water before observed under light microscope. Some samples were then stained by Sudan IV solution (0.5% w/v, in ethanol and glycerin 1:1) and observed under a light microscope again. Separate sections were stained by phloroglucinol-hydrochloride acid (HCl) (0.1% w/v, in 6% HCl and ethanol), for observing lignification under a light microscope. Images were taken using both 25X and 40X magnifications.

Results and Discussion

Dissecting and staining method for microscopy-based analyses of different zones were established at pre-harvest season.

Potential abscission zones were monitored through pre-harvest season, and four zones were selected based on literature. They are labeled as fruit abscission zone (FAZ), peduncle abscission zone (PAZ), secondary abscission zone (SAZ), and leaf abscission zone (LAZ) in **Figure 1**.

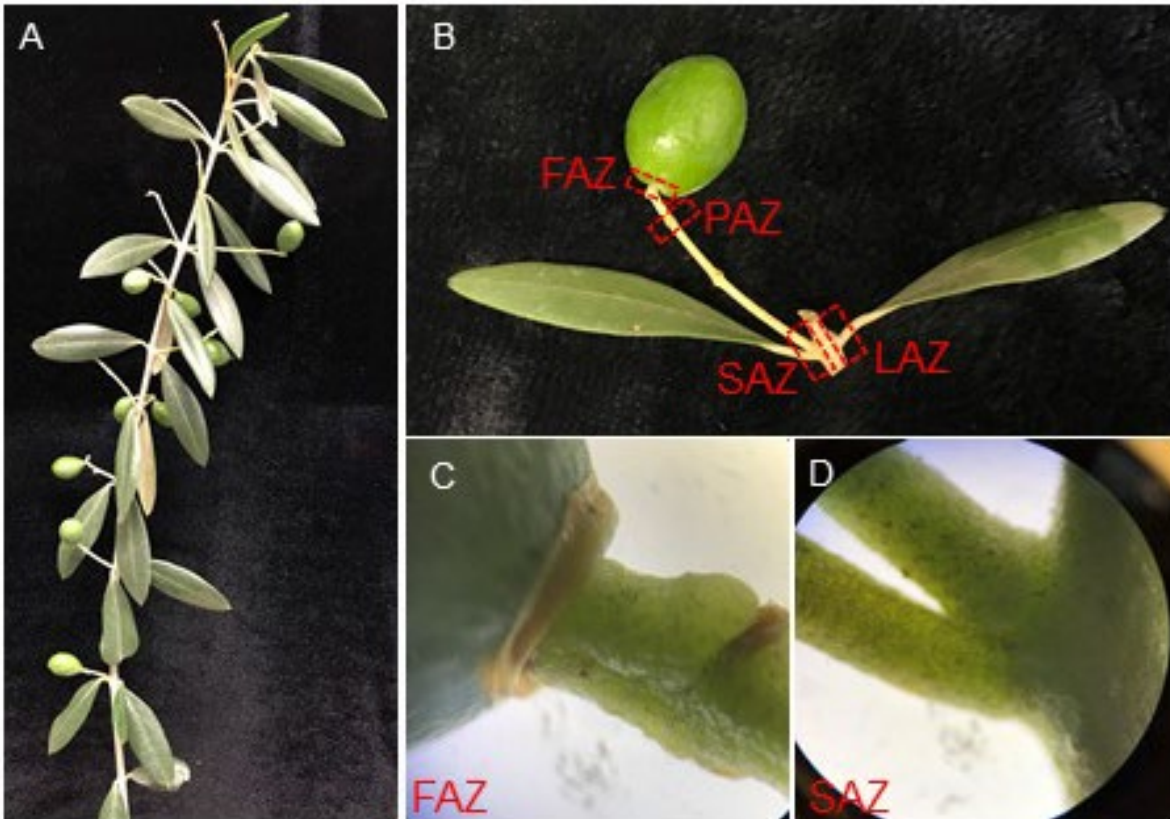


Figure 1. Illustration of regions to monitor. (A) Fruiting branch. (B) Red dashed line indicates potential abscission zones monitored through the season, fruit abscission zone (FAZ), peduncle abscission zone (PAZ), secondary abscission zone (SAZ), and leaf abscission zone (LAZ). (C) Enlargement of fruit abscission zone (FAZ). (D) Enlargement of secondary abscission zone (SAZ).

Fruit and leaf detachment forces, and leaf drop rate

Over 90% of fruits in the collection bin were found to detach from the tree via the fruit abscission zone (FAZ), where a small portion detached at the peduncle abscission zone (PAZ) and the secondary abscission zone (SAZ) (**Figure 2B**).

The fruit detachment force was recorded by the Ferguson group. Leaf drop rate among treatment groups and control will be monitored in December. On the day of harvest, four biological replicates of leaf branches with forty leaves in total were collected from each treatment group for leaf

detachment force measurement, and no significant differences were found among the treatment groups and the control (**Figure 2C**).

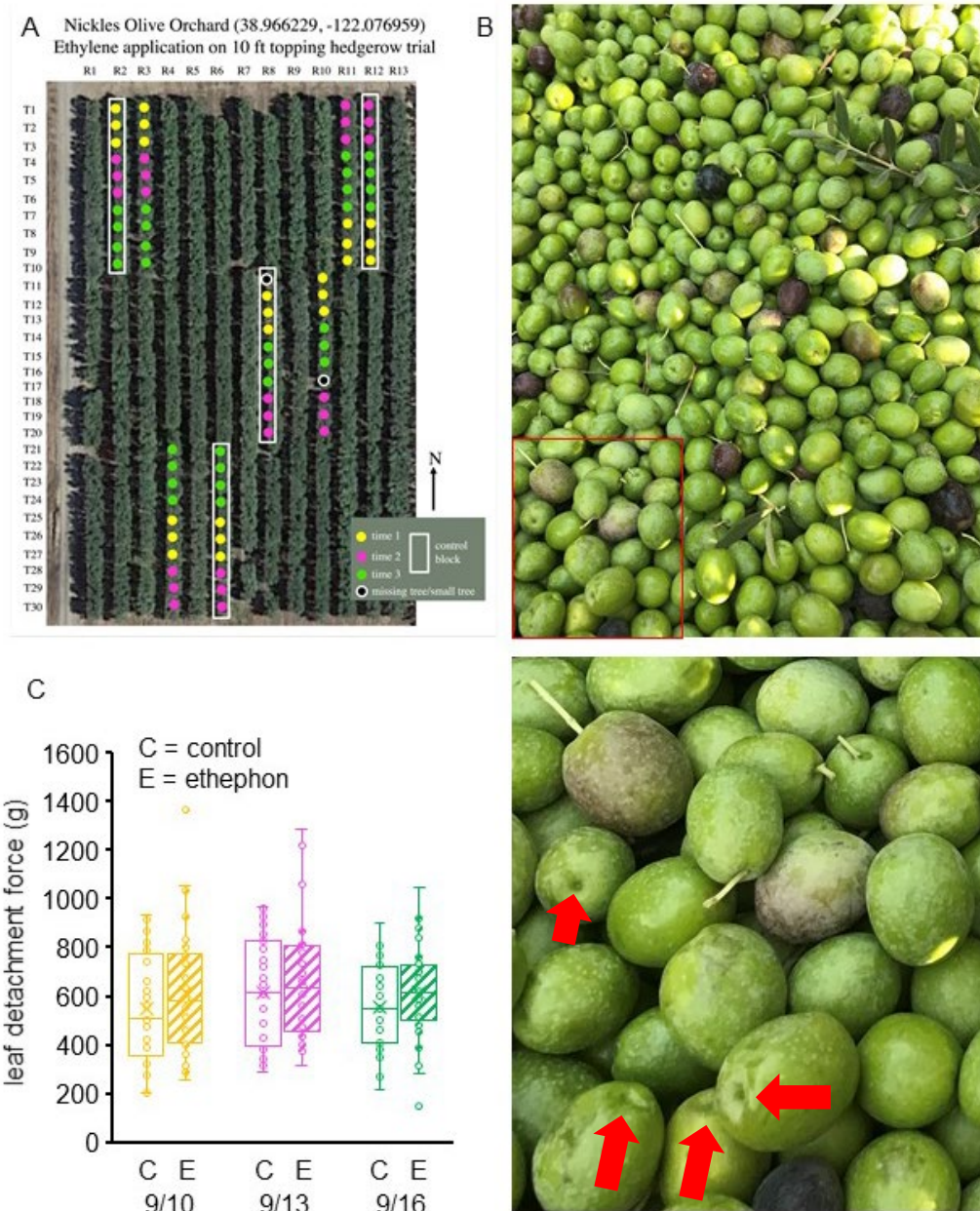


Figure 2. Ethephon treatment for mechanical harvesting of table olives. (A) Ethephon and water application plan before harvest (coordinated with Ferguson Lab). (B) The majority of fruit detachment from the tree occurs at the fruit abscission zone (FAZ) during mechanical harvest, with red rectangular region of the photo enlarged. Red arrows indicate the detachment of fruit at FAZ. (C) No significant decrease of leaf detachment force was observed among treatment groups and controls on the day of harvest.

Lignification and suberization was not detected throughout the pre-harvest season at all the potential abscission zones.

In order to monitor the structural changes involved in fruit abscission, different dyes were employed to indicate the general structure and polymer deposition. Toluidine blue was used to obtain a general structure overview of the four different abscission zones. Sudan IV and phloroglucinol-hydrochloride acid were used as indicators of suberization and lignification, respectively. No lignification and suberization was detected at all the potential abscission zones in untreated samples, until 18 weeks post-anthesis, one week before the mechanical harvest (Figure 3).

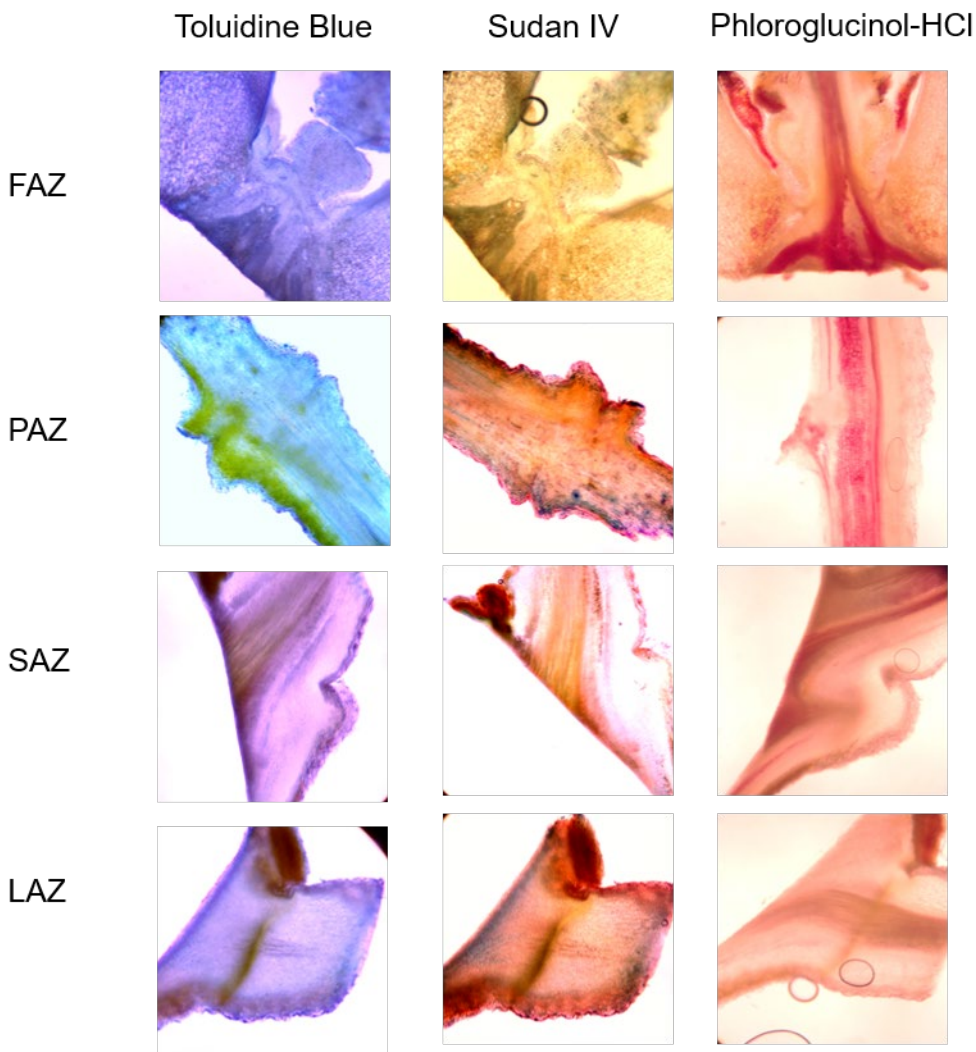


Figure 3. Toluidine blue, Sudan IV, phloroglucinol-HCl staining of all potential abscission zones of untreated samples from 18-week post-anthesis fruit branches. (25X, bright view).

Preliminary data indicate structural changes in response to ethephon treatment as a function of accumulated heat unit

On the day of harvest, September 16th, detachment of cell layers was observed in the FAZ of samples treated by ethephon, as indicated by the arrow in **Figure 4**. No suberization via Sudan IV staining was found among the treatment groups and the control at all abscission zones (**Figure 5**). In addition, lignification of FAZ was found in the same treatment group samples (**Figure 6**), indicated by the dashed line, and enlargement of lignified cells are also shown in a separate panel (**Figure 6**).

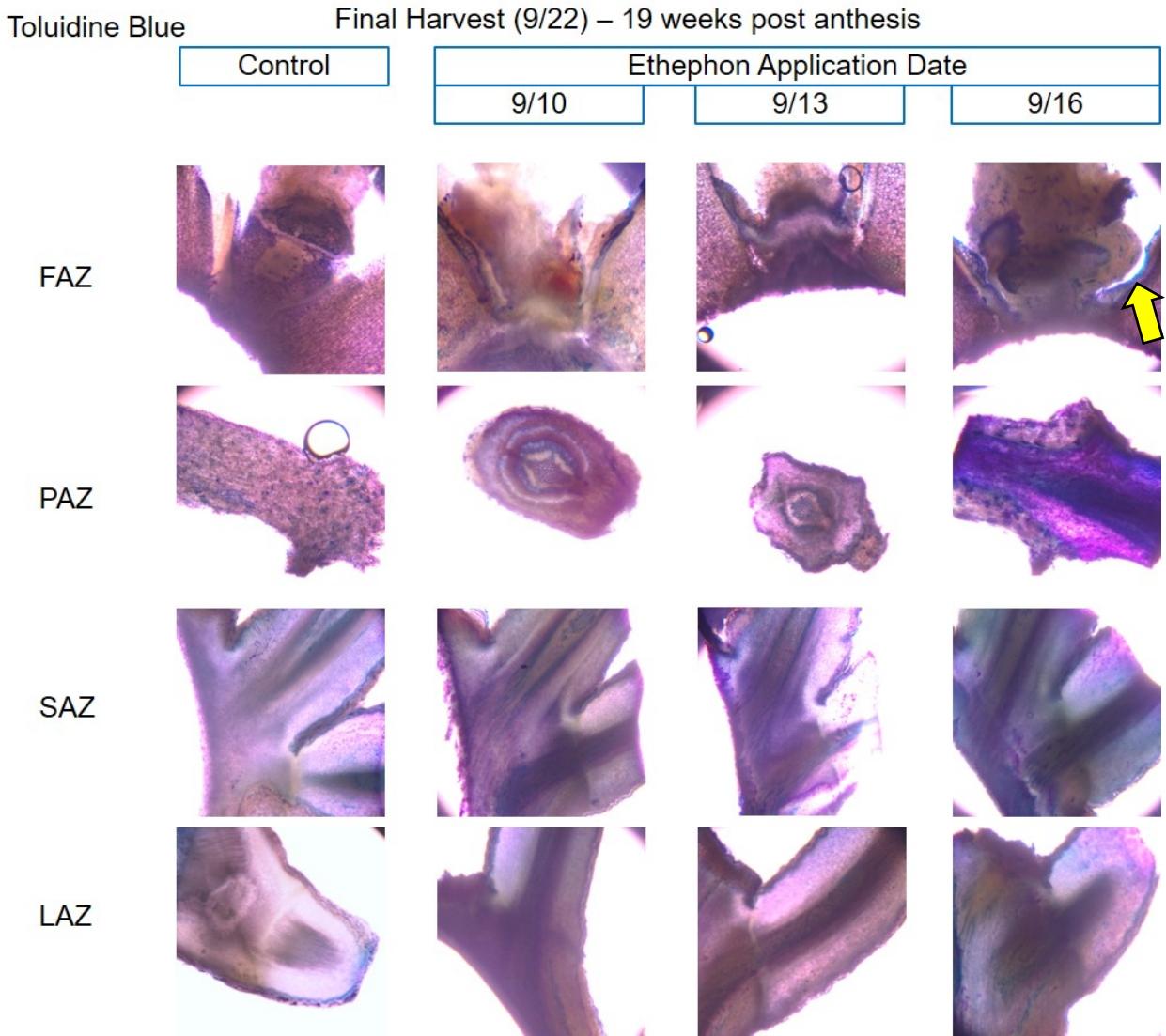


Figure 4. Toluidine blue staining of all potential abscission zones of untreated samples and by ethephon treated samples on different dates (19-week post-anthesis fruit branches, 25X, bright view). Yellow arrow indicates detachment of cell layers.

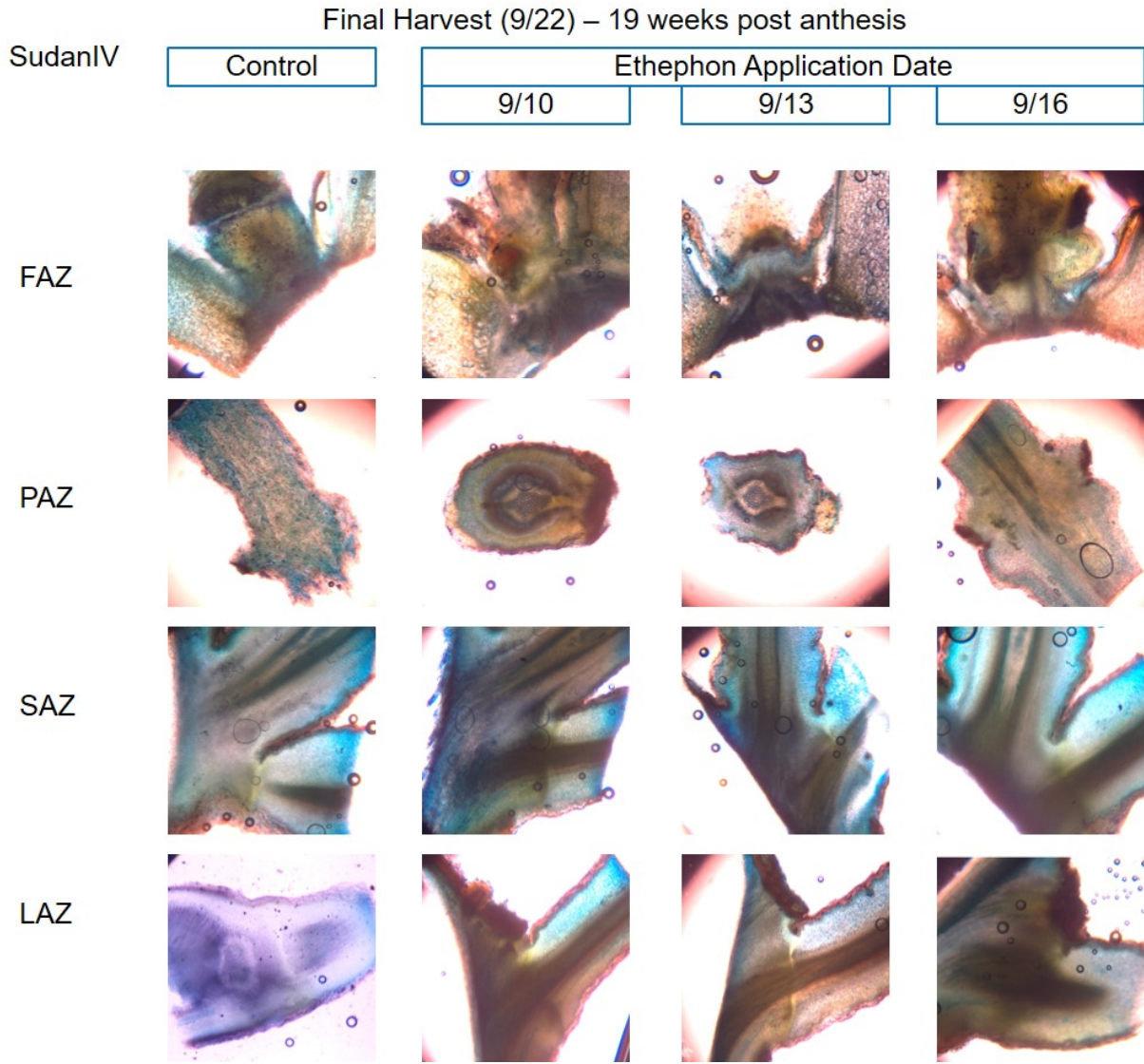


Figure 5. Sudan IV staining of all potential abscission zones of untreated samples and samples treated by ethephon on different dates (19-week post-anthesis fruit branches, 25X, bright view). The same samples were used in **Figures 4** and **5**, with **Figure 5** showing co-staining of toluidine blue and Sudan IV.

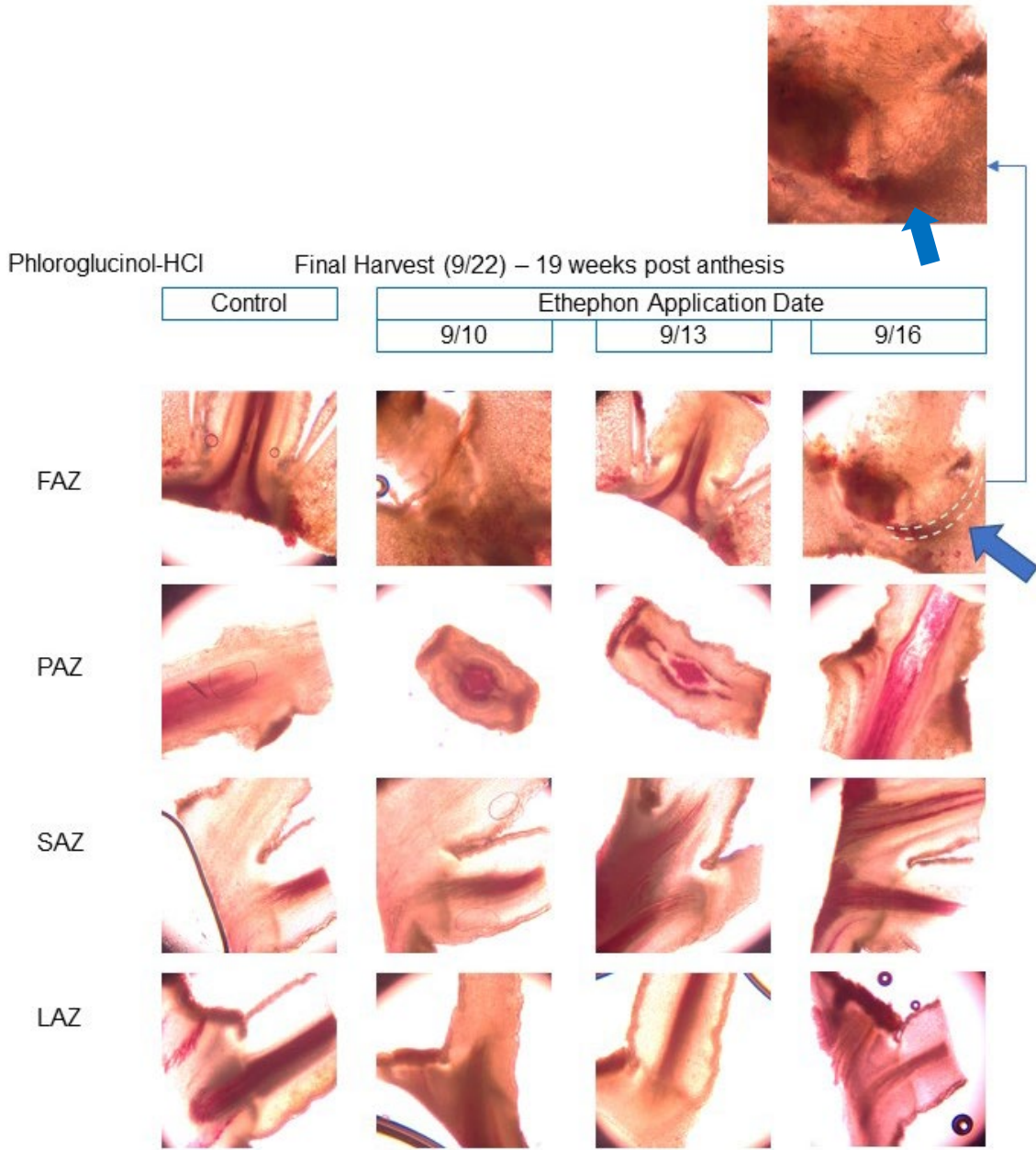


Figure 6. Phloroglucinol-HCl staining of all potential abscission zones of untreated samples and samples treated by ethephon on different dates. Lignified cells in FAZ are indicated by an arrow. (19-week post-anthesis fruit branches, 25X, bright view).

Future Plan

Different levels of lignification of FAZ were observed among the ethephon treatment groups and untreated controls in the samples collected on the day of harvest. We will investigate ten more biological replicates for FAZ of each treatment and control group, using toluidine blue and basic fuchsin staining, in order to have a more accurate estimation for the degree of lignification in the whole population, in response to ethephon application, on different ATU.

RNAseq will be performed on the samples collected on the harvest day, as indicated in the methods, to identify differential expression of genes at the selected zones in response ethephon treatment.

In summary, our results in coordination with Ferguson group, will provide both a whole tree scale and microscopic scale analyses on the effect of ethephon treatment in mechanical harvesting of table olives. Overall, the study will provide a better understanding of both physiological and anatomical changes in response to ethylene, as a function of accumulated heat units. Once concluded, our results will be summarized in a manuscript for publication.

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*****INFORMATION ONLY*****

2022 Project Proposals

TOPIC	LEADERS	AMOUNT
Management of Foliar Diseases of Olive-A. Olive Knot and B. Evaluation of new fungicides for control of olive leaf spot	J.E. Adaskaveg	\$9,000
Epidemiology and Management of Olive Knot Caused by <i>Pseudomonas Savastanoi</i> pv. <i>Savastanoi</i>	J.E. Adaskaveg	\$21,250
Remotely Sensed Olive Crop Mapping for Regulatory Compliance, Water Resource Management and Decision Support	Land IQ	\$21,100
Managing Alternate Bearing in Olive with PGRs and Pruning	Carol Lovatt Elizabeth Fichtner	\$29,217
Characterization of Olive Fruit Abscission Zone in Response to Timed Ethylene Applications and as a Function of Accumulated Heat Unit and Fruit Removal Force	Georgia Drakakaki Louise Ferguson	\$115,151
Precise Water Management Strategies for Table Olive Orchards in California	Giulia Marino Ken Shackel	\$46,610.10
Combining Limb Shaking and Canopy Shaking for Harvesting Mature Olive Trees	Reza Ehsani Louise Ferguson	\$34,902
Southern San Joaquin Valley Olive Fruit Fly Monitoring	Jim Stewart	\$11,000
Sacramento Valley Olive Fruit Monitory Project	Ernie Simpson	\$9,250
Total * budget estimate; actual budget pending on results		\$297,480.10

California Olive Committee Research Priorities for 2022

The California Olive Committee Research Subcommittee met and established the 2022 research priorities. These priorities must be conducted only on Manzanillo and Sevillano ripe olive varieties. The priorities are:

- Olive Fruit Fly Trapping
- Olive Fruit Fly Management Techniques
- Management of olive knot
- Management of peacock spot
- Evaluation of drone technology and satellite mapping
- Mechanical Harvesting on existing and new high density orchards
- Loosening Agents
- Managing Alternate Bearing
- Mechanical harvesting transition
- Canopy Management
- Olive DNA evaluation
- Pruning Management in conjunction with deficit irrigation

Please email proposals to eoliver@calolive.org no later than **OCTOBER 31, 2021 at 5:00 PM PST**. Please feel free to contact our office with any questions. We look forward to reviewing the proposals.

Respectfully,

Elise Oliver

Program Supervisor

California Olive Committee

University of California
Division of Agricultural Sciences**PROJECT PLAN/RESEARCH GRANT PROPOSAL**Project Year: 2022 Anticipated Duration of Project: 1st year of 2 yearsPrincipal Investigators: J. E. AdaskavegCooperating: H. Förster, D. Thompson (UC Riverside)Project Title: Management of foliar diseases of olive – A. Olive knot (see Separate submission) and B. Evaluation of new fungicides for control of olive leaf spot (Supplemental Proposal)Keywords: Chemical and biological control**JUSTIFICATION/ BACKGROUND**

Olive leaf spot or peacock spot, caused by the fungus *Fusicladium oleagineum* (syn. *Spilocea oleaginea*, *Venturia oleaginea*), is a sporadic disease of olive trees in California. In years with favorable environmental conditions, an orchard may lose 9 to 15% of its leaves and 10 to 20% of the fruiting twigs if the disease is not managed. Excessive leaf loss can also result in more olive knot because leaf scars are sites for bacterial infection. Symptoms most commonly develop on the leaf blade but are also found on petioles, fruit, and fruit peduncles (stems). At first, lesions are inconspicuous, superficial, sooty blotches. Later they become dark green to black circular spots containing mycelium and conidia (Fig. 1), and spots are surrounded by yellow halos. These lesions resemble the spot on the tail of a peacock, and hence the name peacock spot. With numerous lesions, the leaf becomes chlorotic and falls.

Leaves in the lower canopy are more severely affected where the humidity is higher, resulting in greater defoliation. Defoliated twigs often die later in the summer. Leaf infections occur on the upper surface and seldom penetrate beyond the epidermal layer. Once the leaf drops, however, the fungus colonizes the internal leaf tissues forming a dense mass of stromatic tissue. The sexual state of the pathogen has not been observed. Olive cultivars vary in their susceptibility. Mission is the most susceptible followed by Manzanillo and to a lesser extent Sevillano, but all cultivars are generally susceptible.

Leaf drop occurs mostly in late spring and summer. Infected leaves remaining on the tree start sporulating along the margins of lesions in the fall. Rainfall and wind-driven rain are the main dissemination methods, whereas wind alone is not effective in detaching and disseminating conidia. In California, the disease starts in the fall and winter and continues in the spring. Temperature is important but often is not limiting the development of the pathogen, but rainfall is essential for infections to occur. High temperatures are more limiting to spore germination and mycelial growth than low temperatures. The optimum temperature for growth of the fungus is 21°C, but growth can occur at 6 to 28°C. The minimum duration of leaf wetness for spore germination is 48 h at 16°C, 24 h at 20°C, or 36 h at 24°C. The incubation period is 12 to 19 days over a temperature range of 10°C to 25°C.

Currently available chemicals for managing the disease are copper and lime sulfur. Bordeaux mixtures or fixed coppers are commonly used to prevent copper injury. Lime sulfur can also eradicate the fungus in leaf tissue, but lime sulfur is difficult to work with and requires extra protective equipment for workers. Timing of fungicide treatments in California include a postharvest application and an early spring application. Others, however, have indicated that spring treatments are less effective. Use of copper treatments at these time periods corresponds with olive knot management timings. With more regulations concerning the use of copper (new copper limits for agricultural uses) and lime sulfur, alternative fungicides are needed that are highly efficacious and persist for extended time periods to prevent infections over the winter and spring. In 2018, the multisite mode of action (MOA) fungicide Ziram and a pre-mixture of two single-site MOA fungicides, Inspire Super, as well as in September 2020, the premixture Quadris Top and the single-site mode of action fungicide Syllit 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 2020/21. UPL has indicated that they support registration of polyoxin-D, but it will take over a year to pursue full registration (i.e., Section 3). Polyoxin-D is exempt from tolerance, but EPA has to review the request of adding olives to the fungicide label. To ensure availability of this fungicide in the coming year, UPL suggested that a Special Local Need registration be requested. Research on these fungicides needs to continue to provide efficacy data over several years and to develop use strategies (i.e., timing, adjuvants). This proposal is to follow through on planned registrations until they are available to the industry.



Fig. 1. Range of symptoms of Peacock spot caused by *Fusicladium oleagineum*.

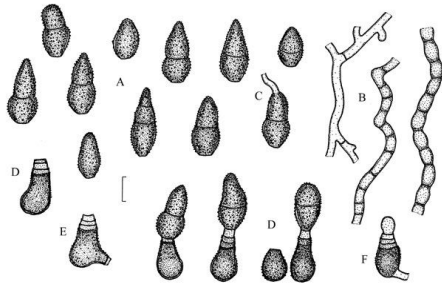


Fig. 2. *Fusicladium oleagineum*. A - conidia, B - superficial septate hyphae, C - germinating conidium, D - conidiogenous cells with several conspicuous annellations, E - percurrent proliferating conidiogenous cell, F - conidiogenous cell arising from a hypha. Scale = 10 μ m.

OBJECTIVES

1. Evaluate the performance of new and older fungicides in field trials.
 - a) Multisite MOA fungicides - Dithiocarbamates (ziram) (FRAC Code – M3) and ziram+copper (FC M1/M3) (Second year data needed for this tank mixture)
 - 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. Submit a Section 24c special local need registration request for polyoxin-D on olive.

PLANS AND PROCEDURES

1. a,b. Evaluate the performance of new and older fungicides in field trials. In studies in commercial olive orchard where the disease is known to occur and in an experimental orchard at UC Davis, fungicides including ziram (Ziram - FC M3), ziram+copper (FC M1/M3), 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.

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. Ziram and Inspire Super (difenoconazole/cyprodinil) were nominated and approved in the IR-4 program in September 2018 with GLP residue trials in 2019 and 2020 and registrations planned in 2023. In 2020, Quadris Top (difenoconazole/cyprodinil) and Syllit (dodine) were accepted into the IR-4 program with residue trials planned in 2021 and 2022. We asked IR-4 to petition ChemSAC to forego the GLP residue studies due to the existing international tolerance for dodine. This was approved, and UPL submitted the product for full federal registration and state approval on olive in 2023. UPL (ziram, polyoxin-D, dodine) and Syngenta (difenoconazole/cyprodinil, or difenoconazole/azoxystrobin) fully support their respective products for registration on olive. As explained above, polyoxin-D will be registered as a biopesticide with exemption from tolerances in the United States. UPL has indicated that they would support a special local need or Section 24c registration of polyoxin-D. This proposal in part includes preparing the Section 24c proposal to CDPR and EPA to ensure availability to California olive growers in the fall of 2022. The budget was minimized to allow for two efficacy trials to be done in 2022 and to provide stewardship in the registration of the five fungicides in the registration process.

REFERENCES

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Budget Request: (Supplemental to the Olive Knot Proposal)

Budget Year: 2022

Funding Source: California Olive Commission

Salaries and Benefits:	Post-Docs/RAs	<u>5,000</u>
	Lab/Field Ass't	<u>0</u>
	Subtotal	<u>5,000</u>
	Employees' Benefits	<u>3,000</u>
	Subtotal	<u>8,000</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>1,000</u>
Department Account No. _____	Total	<u>9,000</u> *

*Note: This budget can also be split in half between COC and COOC.

James E. Alvarado

Dept. Chair, Howard Judelson *Howard Judelson* Date: Oct. 28, 2021
 (Riverside Campus)
 Liaison Officer _____ Date: _____

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

Project Year: 2022 Anticipated Duration of Project: 2st 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

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, however the PRIA date was again postponed until early 2022 for these crops. The olive submission of kasugamycin to the EPA was delayed because new GLP residue trials and laboratory analyses had to be done because of an IR-4 analytical laboratory failure and these studies were completed in 2019, an IR-4 petition was prepared in 2020/21, and finally submitted in the summer of 2021. Kasugamycin would greatly complement current copper sprays and could be used in rotation or mixtures with copper.

A second antibiotic, oxytetracycline, is also being pursued for registration on olives through the IR-4 program. The IR-4 petition for oxytetracycline was submitted to EPA in late summer 2020 and the registration was scheduled for Oct. 2021, but it is now expected on olive in early 2022. 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. **Studies in 2021 showed a synergistic interaction between oxytetracycline and dodine, and this mixture treatment was highly effective against olive knot.** Since this compound is being registered for peacock spot, and it also has high efficacy against this disease, we plan to continue to evaluate it as a bactericide alone or in combination with other antimicrobials (i.e., copper, antibiotics, and food-grade bactericides).

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 2021, we evaluated the GRAS compounds nisin, ϵ -poly-L-lysine (EPL), 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 and 2021, disease control was comparable to that of copper or kasugamycin treatments using high rates of EPL 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 EPL 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 (*see* Peacock spot proposal).

Therefore, we showed that field performance of new bactericides can be improved, and we are working to formulate nisin and EPL 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 or adjuvants (9) to prevent photo- or UV-degradation, and in mixtures with other bactericides (e.g., kasugamycin) or fungicides (e.g., 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 potentially 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, ϵ -poly-L-lysine (EPL), mixed with the sanitizers capric/caprylic acids (Dart) alone or combination and in mixtures with selected adjuvants or other products such as the fungicide dodine (that is being registered as a fungicide on olive), that also has bactericidal properties to improve field stability and efficacy of the antimicrobials.
 - 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 fungicides (e.g., **dodine**) 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, ϵ -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).

2) 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. Follow-up requests for registration on olive were made to EPA and UPL in the summer of 2021.
- b) Optimize the efficacy of oxytetracycline and kasugamycin, in mixtures with **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 EPL (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, EPL 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, oxytetracycline, and dodine.

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, but now it has changed to late fall 2021 or winter 2022 along with the walnut petition.

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 2021 with a PRIA date of November 2022. Syllit is being federally registered on olive based on IR-4's submission to EPA through the Chemistry Science Advisory Council (ChemSAC) program in early 2021, and olive is being added to the label. This label amendment was submitted by IR-4 to the EPA on July 2, 2021. The current PRIA date is November 2022. UPL also requested a concurrent review of kasugamycin and dodine in the state of California this summer (2021).

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/early 2022 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 also pending in late 2021/early 2022. Kasugamycin showed high activity against olive knot especially in mixtures with copper; whereas oxytetracycline also showed consistent high activity in mixtures with low rates of copper and synergistically in mixtures with dodine. These are exciting developments for the olive industry.

We will continue to explore and evaluate other potential bactericide products that include the natural GRAS products nisin and EPL in mixtures with the sanitizers capric/caprylic acids. Nisin and EPL 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.

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Budget Request:Funding Source: California Olive Commission and California Olive Oil Commission**Budget Request with UC indirect costs:**

Budget Year: 2022 Funding Source*:	OOC	COC	Total Budget
Salaries and Benefits: SRA/Postdoc	5,000	5,000	10,000
Lab/Field Ass't	0	0	0
Subtotal	5,000	5,000	10,000
Employees' Benefits**	3,000	3,000	6,000
Subtotal	8,000	8,000	16,000
Supplies and Expenses	0	0	0
University Land and Orchard charges	1,000	1,000	2,000
Operating Expenses/Equipment Travel	0	0	0
Travel	1,000	1,000	2,000
Direct Cost Totals	\$10,000	\$10,000	\$20,000
Off Campus IDC @ 11%		1,150	1,150
Total Budget Requested	\$10,000	\$11,150	\$21,150

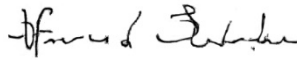
Date: Oct. 28, 2021

Originator's Signature (PI)

Dept. Chair

(Riverside Campus)

Liaison Officer

Date: Oct. 28, 2021

Date: _____

CALIFORNIA OLIVE COMMITTEE

PROJECT PLAN/ RESEARCH GRANT PROPOSAL

Project Year: 2021-2022

Anticipated Duration of Project: 1 Year

Title: Remotely Sensed Olive Crop Mapping for Regulatory Compliance, Water Resource Management and Decision Support

Principle Investigator: Joel Kimmelshue, PhD, CPSS

Land IQ
2020 L Street, Ste 210
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916-517-2482
jkimmelshue@landiq.com

Cooperating Investigators:

Casey Gudel, MS; Mica Heilmann, CPSS, CPESC; Zhongwu Wang, PhD; Seth Mulder, MS, CPAg, CCA; Chris Stall, MS; Diya Chowdhury, MS

2021-2022 Funding Request: \$21,100

BACKGROUND/JUSTIFICATION

Land IQ developed a remotely sensed California statewide land use mapping dataset for the California Department of Water Resources (DWR) covering the following crop years and systems:

- 2014 Main Season Summer Crop
- 2016 Main Season Summer Crop
- 2017/2018 Hydrologic Year (includes multi-cropping)
- 2018/2019 Hydrologic Year (includes multi-cropping)
- 2019/2020 Hydrologic Year (includes multi-cropping)

This land use dataset is the standard by which the state of California provides comprehensive land use for multiple purposes that use and manage various water resources.

Spatial land use information, including agricultural and other land uses, are essential for a number of regional and statewide regulatory, planning and resource management purposes, marketing efforts, crop forecasting, and land use change. Accurate and timely land use information is the foundation of these analyses and is vital to accurate decision-making and modeling processes.

Increased availability of digital satellite imagery, aerial photography, and new analytical tools make remote sensing land use surveys possible at a field scale (e.g. as fine as 1.0 acres and less). These technologies allow accurate, large-scale crop and land use identification to be performed at time increments as desired and make possible comprehensive statewide crop by crop land use information available for the first time. The most recent effort classified over 10.4 million acres of agriculture into 50+ crop categories that align with the DWR standard legends, with a minimum field size of 2 acres (and for certain crops, less) with a classification accuracy exceeding 97% statewide.

Agricultural land use is continually changing. It is important to understand the impacts of crop type and

distribution, crop change, acreage, permanent crop age, irrigation method, and associated production practices. These data can be used to inform decisions on water resources management, marketing activities, ownership, location, greatly refine hydrologic models, evaluate groundwater recharge suitability, and better assess the role of agriculture in the management and sustainability of surface and groundwater resources.

OBJECTIVES

The objective of this proposal is to understand the dynamics of changing acreage and location of crops to help the California Olive Committee make critical decisions on environmental, market, research, and production issues.

Growers and processors alike benefit from understanding the impacts of land use, crop location, crop change, acreage, crop age and best management practices on environmental attributes and impacts such as water quality, air quality, disease, and/or pest vectors. Conversely, environmental factors, such as climate change and sensitive habitats, increasingly influence how much and most importantly, where specific crops are grown.

The Land IQ mapping conducted for the California Department of Water Resources currently includes the crop category of Olives (Figure 1), which includes both table olives and olives for oil. While these olives are generally grown regionally, Land IQ proposes utilizing industry representatives for identifying which blocks are grown for table and which are grown for oil.

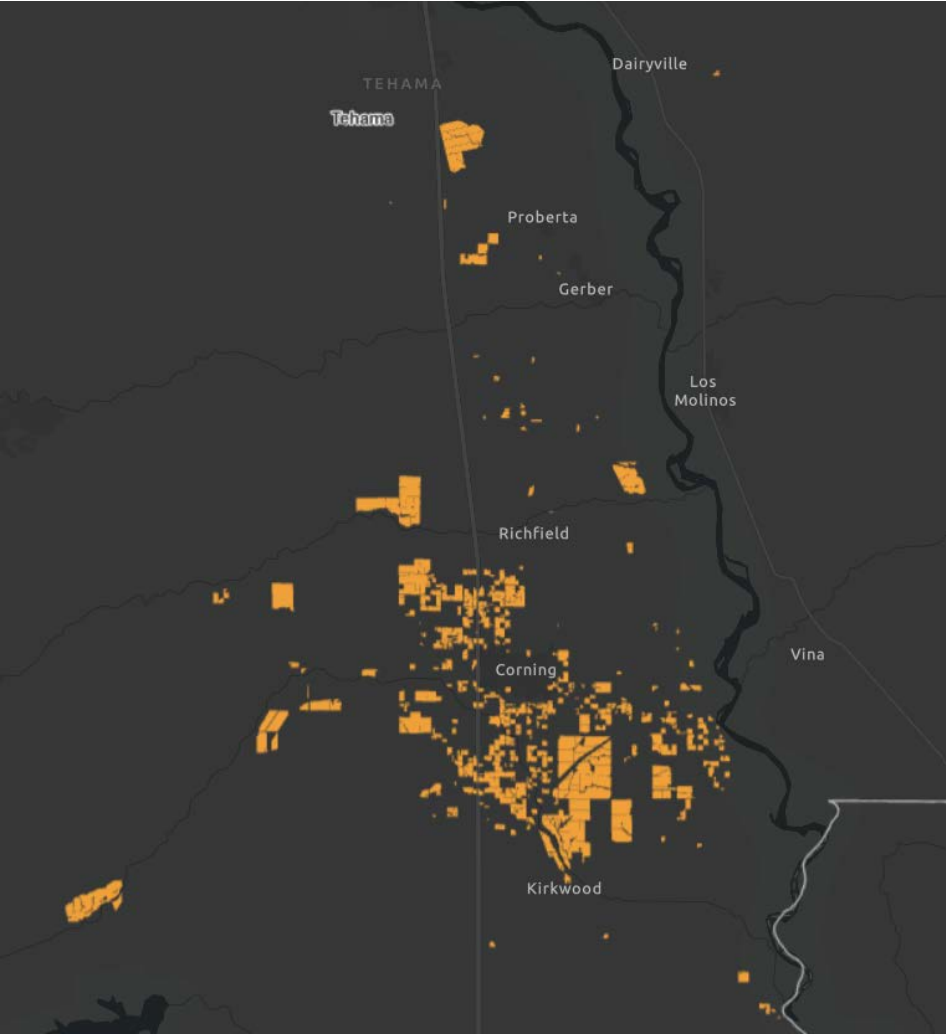


Figure 1. Example of Land IQ Olive Mapping

Once olives are mapped, further analysis can be conducted to determine the age of the crop utilizing a backwards looking time series analysis on available imagery as far back as 1984. Each crop is analyzed for spectral and textural signature changes from a crop to bare ground. At that point, this is considered the planting date (Figure 2).

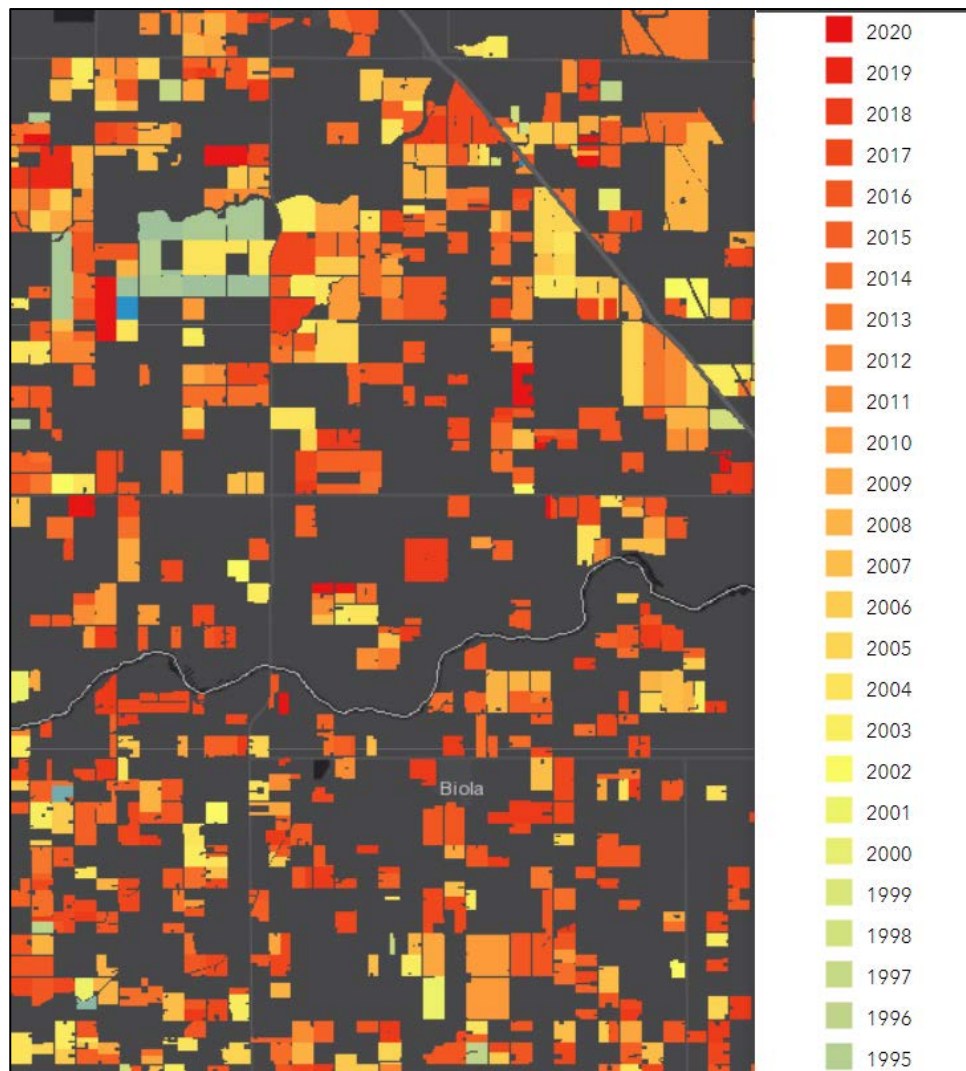


Figure 2. Example of Land IQ Age Analysis in Almonds.

Growers and commodity groups need to understand the impacts of land use, crop location, crop change, acreage, tree age, proximity to other crops and urban areas, and best management practices on environmental attributes and impacts such as water quality, air quality, disease, and/or pest vectors. Conversely, environmental factors, such as climate change and sensitive habitats, increasingly influence how much and where these crops are grown. For these purposes, as well as many others, as these spatial mapping layers continue to be developed, it is important for the information to be accessible by designated end users to aid in effective decision-making and other applications.

The development of a web mapping application that incorporates the statewide mapping effort, in addition to other spatial layers, provides the California Olive Committee with a comprehensive, efficient, protected, updateable, and seamless web-based viewer to access the data and overlay with other publicly available spatial mapping resources.

The web map application would have the ability to incorporate multiple data sets, including the following:

- Base mapping products:
 - 2020 Statewide Olive Mapping
 - Individual field age/planting date
 - Final Differentiation between oil and table olives
- Additional spatial layers:
 - Irrigation district boundaries
 - Sustainable Groundwater Management Act (SGMA) boundaries
 - Irrigated Lands Regulatory Program (ILRP) coalition boundaries
 - Political boundaries
 - Air quality districts
 - Township, range, section and other legal boundaries
- Environmental/Surface spatial information:
 - Groundwater recharge areas
 - Soil type
 - Surface hydrology
 - ET zones
 - Average and historic rainfall

Figure 3 provides an example of a web mapping application designed for the California Avocado Commission and related layers.

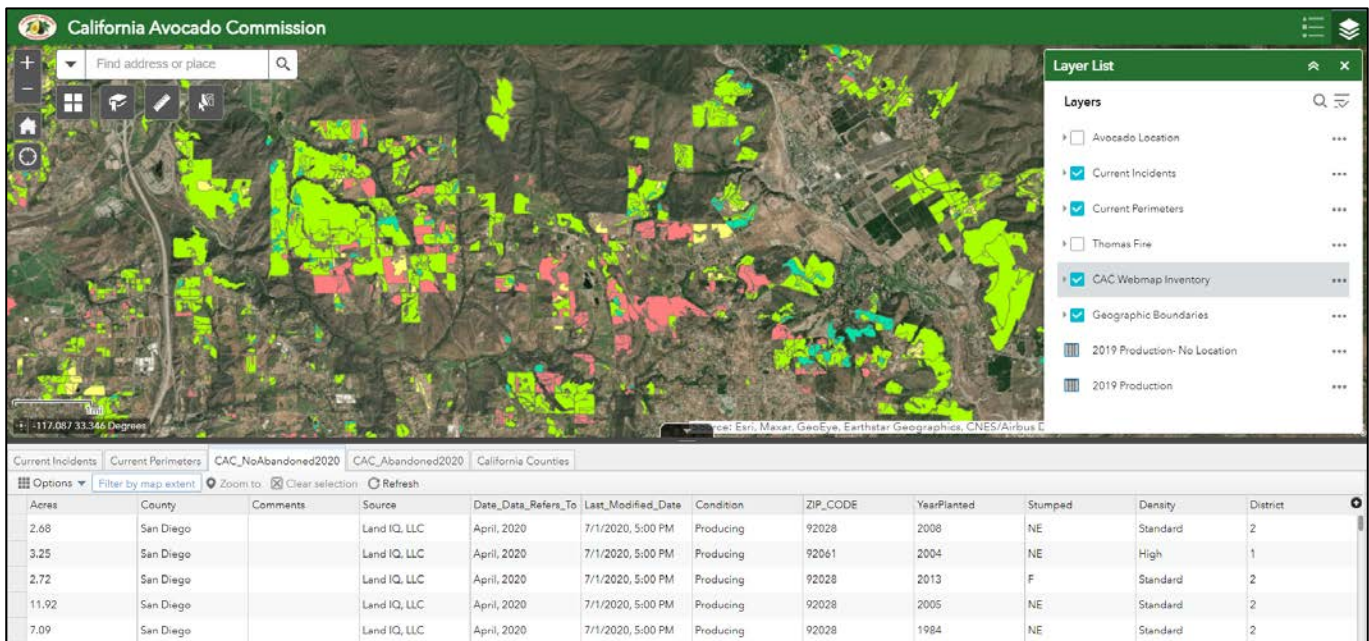


Figure 3. Web Mapping Application and Example Data from the California Avocado Commission

This effort will include the first-year maintenance costs of necessary software, hardware, data management, login credentials management, data protection, and support requests. These maintenance fees will be due after the first year of web map operation and annually thereafter as long as the client desires to maintain the web map. Annual maintenance fee includes:

- Web mapping software license fees and data hosting hardware costs
- Uploading of new base image maps, street layers, updated irrigation district boundaries, and updated regulatory (e.g., Irrigated Lands Regulatory Program, Sustainable Groundwater Management Act, etc.) boundaries, political boundaries, watershed boundaries, irrigation district boundaries, etc. that are agreed to as initial additional layers in the original web map itself
- General data management and routine QA/QC and clean-up of the underlying base layer data

BUDGET REQUEST

The following table represents the estimated cost to fulfill the scope of work provided above and amounts to \$21,100. Please note, Task 4 is not included in this task because the first year annual maintenance cost for the web mapping application viewer is included in the first year overall cost.

Task	Description	Cost	Mapping Water Year to be Completed
1	Statewide Olive Mapping Differentiation Into Oil and Table	\$ 9,400	2020
2	Age Classification	\$ 4,400	Thru 2020
3	Web Mapping Application	\$ 7,300	2020
4	Annual Maintenance*	\$ 3,200	N/A

***Annual maintenance costs are provided for informational purposes and are for future years only. The annual maintenance costs are subject to change, however no more than 4% annually.**

CALIFORNIA OLIVE COMMITTEE

PROJECT PLAN/RESEARCH GRANT PROPOSAL

Project Year: 2022

Anticipated Period of Performance: year 3 of 3

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

Project Leaders: Elizabeth Fichtner and Carol Lovatt

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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

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

Commodity: Olive

Relevant AES/CE Project No.: 4556-H

Year Initiated: 2020 Anticipated Duration of Project: 3 crop years 2022 request: \$29,217

Problem and Previous Research Accomplishments: *Problem.* Alternate bearing (AB), production of a heavy, high yield "ON crop" followed by a light, low yield "OFF crop", is a significant economic problem. In ON-crop years, trees produce a large number of small size fruit with reduced commercial value. In OFF-crop years, trees produce large fruit, in some cases too large, but there are too few fruit to provide growers with a good income. In addition, our research has documented that fruit quality is reduced in off-crop years. The large fruit of OFF-crop trees turn black earlier in the season further exacerbating the problem of too few commercially valuable fruit. For olive, the ON-crop takes longer to mature, attain size, and accumulate oil. The delayed harvest further reduces floral intensity the following spring. Alternate bearing often occurs beyond the tree or orchard level, but rather is synchronized across geographic regions, particularly when environmental conditions initiate AB by causing an OFF crop (i.e., heat at bloom in 'Manzanillo' orchards). An industry-wide shortage of fruit in the OFF-crop year has a negative economic impact on every step in the production chain from farm to consumer, including orchard management, harvesting, packinghouse/processor operations, manufacture of value-added products, marketing, and consumer prices, the summation of which jeopardizes the stability and sustainability of the olive industry. Climate is the major factor initiating AB. High or low temperatures, water-deficit stress or excessive winter rain causing soil hypoxia etc. that significantly reduce 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.

Knowledge obtained from our ongoing research. In an alternate bearing orchard, return bloom is dramatically reduced on bearing shoots of ON-crop trees, the majority of shoots on ON-crop trees, due to the combined effects of the total number of 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. These two combined effects of fruit in the ON crop (i) inhibit summer vegetative shoot growth and thereby reduce the number of nodes that can produce floral (inflorescence) buds the following spring, as first demonstrated by Sibbett (2000) and confirmed by our research, (ii) increase floral bud abscission, (iii) inhibit flowering by preventing transcription of key genes required for inflorescence development and flower formation, and (iv) reduce bud break in the spring following the ON-crop year, all of which were first identified by our COC funded research (Fichtner and Lovatt, 2018; Fichtner et al., 2017; Chao, 2014). Note that for 'Manzanillo' olive, the localized effect of fruit set on a shoot is a stronger negative effect on each of the four parameters influencing return bloom listed above than the total number of fruit on the tree (crop load effect). Thus, 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. 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 as 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. Thus, the overall goal of our research is to develop a management strategy that increases the number of non-bearing shoots to the degree necessary to maximize total yield and importantly the yield of commercially valuable size fruit annually such that the sum of two annual yields is greater for our treated trees than the sum of the ON/OFF yields of an alternate bearing cycle.

Summary of the results obtained over the last 4 years (2018-2021). The research we conducted during the past 4 years compared the efficacy of a PGR chemical flower thinning treatment (naphthaleneacetic acid [NAA]) applied at full bloom and mechanical pruning (hedging) done after fruit set (28 days after full bloom) to increase the number of non-bearing shoots on ON-crop trees to increase return bloom and yield compared with untreated ON- and OFF-crop control trees. Trees in all treatments were topped at approximately 14 feet each year. The trees were skirted on July 1, 2020. The objective during the past 4 years 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.

The research was initiated with ON-crop trees, thus in 2018 and 2020, the NAA and pruning treatments were applied to all trees; in 2019 and 2021 trees treated every other year were not treated. Results are summarized in Table 1 for 2019, the first year that trees to be treated with NAA and pruning on one side of the tree and then other side every other year were left untreated, for 2020, the year the other side of the tree was treated, and for 2021, when the other side was left untreated again. ON-crop control trees (Treatment 4) have continued to produce alternating ON and OFF crops. These trees are ON-crop trees in 2021 (Table 1). The OFF-crop control trees (Treatment 1) produced three back-to-back ON crops followed by an OFF-crop in 2021 (Table 1). These differences demonstrate the need for a tool, such as bloom estimate, to guide growers as to when trees should and should not have the crop thinned. The data for 2019, 2020, and 2021 were used to calculate an alternate bearing index for the average estimated bloom as the sum of the east and west

side of the trees, average total yield, and average yield of medium+large size fruit for each 2-year ON/OFF cycle. $ABI = (\text{year 1 bloom or yield} - \text{year 2 bloom or yield}) / (\text{year 1 bloom or yield} + \text{year 2 bloom or yield})$, in which bloom is the sum of the bloom estimated for the east+west sides of the tree and yield is total kilograms of fruit per tree or kilograms of medium+large size fruit per tree and the difference in bloom or yield between years 1 and 2 is expressed as an absolute number. An ABI of zero means no alternate bearing, whereas an ABI of one is complete alternate bearing, i.e., bloom or crop one year, no bloom or crop the other year (Pearce and Dobersek-Urbanc, 1967). For the estimated bloom sum for 2019 (the year following the first treatment applications in 2018) through 2021, the average ABI for bloom for trees treated every other year is 0.26 and 0.29 for NAA and pruning, respectively, which are significantly lower than the ABI for bloom of trees treated with NAA and pruning annually, 0.44 and 0.50, respectively, and the ON-crop control trees (Treatment 4), for which bloom ABI equaled 0.63 (Table 1). There was no significant difference in ABI for the estimated bloom sum among treatments for 2020+2021. The lowest ABI for total yield is for the original OFF-crop control trees (Treatment 1) for both 2019+2020 and 2020+2021. For these periods, trees treated with NAA or pruned every other year have ABIs for total yield intermediate to the OFF- and ON-crop control trees and lower than trees treated with NAA or pruned annually (non-significant) (Table 1). Since 2019, the treatments have been stabilizing the yield of commercially valuable size fruit. The ABI for yield of medium+large size fruit for 2019+2020 and 2020+2021 was 0.46 and 0.67, respectively, for NAA and 0.37 and 0.59, respectively, for pruning every other year compared to 0.70 and 0.73, respectively, for NAA and 0.80 and 0.68, respectively, for pruning annually (Table 1). Thus, the comparison of ABIs for bloom, total yield, and yield of medium+large size fruit provides strong evidence that applying NAA or pruning treatments to one side of the tree and then the other side every other year is more effective in mitigating alternate bearing than applying these treatments annually.

Taken home message. To mitigate alternate bearing reducing crop load with either NAA or pruning one side of the tree and then the other side of the tree gives similar results in most years and both are best done every other year, not annually.

In addition, over the past 4 years, we learned that the NAA and pruning treatments should not be applied on a rigid schedule; for examples: (i) the crop thinning treatments should not be carried out if the bloom intensity is low (OFF, < 2) on the side of the tree to be left untreated; and (ii) the crop load reducing treatments should be used out of sequence when it is necessary to treat an ON-bloom/ON-crop when alternate bearing is reinitiated.

Summary of 2021 results. With this knowledge, the goal in 2021 was to combine the best fruit thinning strategies, respectively, with the foliar-application of the cytokinin-PGR (a 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. The results for the two set of trees were compared to NAA and pruned trees not treated with the cytokinin-PGR and the ON- and OFF-crop control trees. The objective was to increase the 2-year cumulative yield of commercially valuable size fruit to greater than the sum of the ON-/OFF-crop yields in an alternate bearing cycle. The yield results obtained at harvest in 2021 suggest that this goal is attainable (Table 1). The cytokinin PGR (Treatments 5 and 6) significantly increased total yield and yield medium+large size fruit (nonsignificant) relative to their respective counter parts not treated with the cytokinin PGR (Treatments 3 and 4). This preliminary, we will continue to test the efficacy of the cytokinin PGR

treatment to increase the yield of medium+large size fruit when used with NAA and pruning crop thinning treatments relative to their counter parts not treated with the cytokinin.

To increase grower profit, there is still a need to further increase the yield of medium+large size fruit, while maintaining a low ABI. In 2021, as part of our research, we investigated the relationship between total yield and yield of commercially valuable medium+large size fruit to determine at what total yield (kg/tree) the greatest yield of medium+large size fruit is obtained. Using our data set of more than 500 tree-years, median yield was 110 kg/tree for this data set, indicating 50% of the trees in the data set produced ≥ 110 kg/tree but 50% of the trees in the data set produced less. Lower yields are associated with more fruit in larger fruit size categories, i.e., fruit size greater than or equal to extra-large size fruit at harvest. As total yield increases the yield of medium size fruit continues to increase up to total yields of 150 kg/tree; yield of large size fruit is stable at 22 to 25 kg/tree for total yields >110 up to 150 kg/tree. However, at total yields > 120 kg/tree, there is significant increase in the yield small and petite size fruit, making the yield of fruit in these two size categories approximately 50% of the total yield. On average in this data set, maximum yields of medium+large size fruit are between 43-54 kg/tree at total yields between 90-110 kg/tree and 54-56 kg/tree at 110-120 kg/tree. Since total yield > 120 kg/tree increases the yield of small and petite size fruit of limited commercial value to approximately 50% of total yield that contribute to alternate bearing, yields > 120 kg/tree should be avoided. Total yields that stabilize yield annually may benefit from a cytokinin-PGR treatment to increase the yield of medium+large size fruit. **Note:** that low yielding trees produce low yields of fruit in all size categories. This is a limited set of data. We will continue to investigate the relationship between estimated bloom, total yield, yield of commercially valuable size fruit (medium+large) and the severity of alternate bearing to identify the target total yield that minimizes ABI and maximizes yield of medium+large size fruit and net profit. Please advise us if you wish for us to focus on different or additional fruit size categories.

Research Goals, Objectives, Benefits and Anticipated Outcomes for 2022: The goals of for 2022 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 annually at a total yield that 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 and increase canopy light penetration to increase flowering. All trees were skirted in 2020. **2022 Objectives. Objective 1** - To reduce crop load (total number of fruit per tree) and to 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 Liqui-Stik Concentrate[®] NAA (Loveland Products), which is identical to AMVAC's Olive Stop[®]. In fact, AMVAC is the source of NAA used by Loveland Products to produce Liqui-Stik[®]. We will not include Mandolin[®] in our research in 2022 as previously planned because AMVAC recently decided not to register the product for use on olive in the near term. Liqui-Stik[®] will be applied at full bloom according to the manufacturer's instructions, which are identical to those for Olive Stop[®]. To meet this objective, we will also remove fruit by pruning (mechanical hedging) one side

of 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 at return bloom and fruit size (Fichtner and Lovatt, 2018; Fichtner et al., 2017). Applications will be made in 2022 just prior to spring bud break to increase inflorescence number, and just prior to summer vegetative shoot growth, and again just prior to spring bud break in 2023. **Note** that last year, 2021, the NAA and pruning treatments were not applied; the Cytokinin-PGR treatment was applied to a set of trees that had received NAA and pruning treatments in 2020 and will be treated again in 2022. In 2022, we will test the application of treatments on a flexible schedule: for examples, (i) the crop thinning treatments will not be carried out if the bloom intensity is low (OFF) on the side of the tree to be left untreated (< 2); and (ii) the crop load reducing treatments will be used out of sequence when it is necessary to treat an ON-bloom/ON-crop when alternate bearing is reinitiated. The results of the 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. Total yield and fruit size distribution as kg/tree will be determined and used to calculate yield and fruit size distribution as number of fruit per tree; fruit quality will be evaluated for the proportion of green, partially green, partially black and black fruit. Alternate bearing index will be calculated. We will continue to analyze the relationship between bloom sum, total yield, and yield of commercially valuable size fruit with the goal to provide growers with a tool to assist in deciding when to apply a fruit reducing strategy or not. A final cost benefit analysis will be calculated. **Benefits of the proposed research.** (1) In our research, NAA is applied at 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, respectively. (2) Reducing crop load on only one side of the tree every other year reduces the negative effect on final yield compared to treating both sides of the tree in a given year and protects growers from over thinning their orchards. (3) Since the treatments increase the number of non-bearing shoots per tree, they will improve the efficacy of the cytokinin-PGR treatment that increases 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 the cytokinin-PGR treatment 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 at harvest.

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 < 2 on a scale from 0 to 3. This evaluation is not onerous, requiring only a quick walk or drive through a block. We still need to identify an upper threshold value for the bloom estimate that indicates that crop removal treatments need to be carried out.
- Results thus far suggest that NAA inflorescence removal and fruit removal by pruning (hedging) typically resulted in similar return bloom intensity and return total yield and yield

of commercially valuable size fruit. Thus, the NAA treatment can be interchanged with pruning to accommodate tree canopy management in an orchard.

- 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 and 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.
- The 2022 yield data will augment our data set for establishing the year-to-year variability in yield encountered using NAA versus pruning for crop thinning and their effects on the yield of medium+large fruit.
- The 2022 harvest data will quantify the effects of applying the NAA and pruning treatments on one side of the tree and then the other side every other year in combination with the natural cytokinin-PGR product to further test the efficacy and reliability of this treatment to increase yield of medium+large size fruit and proportion of green versus black fruit, without increasing the severity of alternate bearing (ABI).
- Thus, the data will document whether efficacy of the best crop thinning strategy using NAA or pruning is improved by combining it with the application of the natural cytokinin-PGR product.
- The data will quantify the efficacy of the treatments to reduce the severity of alternate bearing (ABI) in ‘Manzanillo’ 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. The strategy would be 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 followed by an ON crop. It would then be used on a regular basis to mitigate high alternate bearing until uniform yields optimizing the yield of commercially valuable size fruit are attained annually. Then the treatment would be stopped. We will provide growers with a set of criteria describing when this point is reached.
- Further, based on the results of this research, we will provide growers with a set of directions for the best way to incorporate pruning into their orchard management practices as an alternative to NAA when mitigating AB or under stabilized yield conditions. Tree crops must be pruned: No light, no flowers, no crop!

Select References:

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BUDGET REQUEST: (Carol J. Lovatt)

Budget Year: 2022

Funding Source: COC

Labor: (Line 1)**\$8,287**

Salary: T Khuong @ \$68,600/yr. x 8% FTE = \$5,488

\$A 5,488

Benefits: TK= \$5,488 x (42% + 9% Vac Accrual = 51%) = \$2,799

\$B 2,799

Subtotal 1 Line 1 subtotal**\$8,287****Supplies, Equipment:** (Line 2)**\$8,550**Supplies: *(be specific. Examples include tape, tags, buckets, traps, safety, chemicals, etc.)* \$C 0Equipment: *(be specific. Examples include balances, meters, devices, etc.)* \$D 0Individual 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**Subtotal 2** Line 2 subtotal**\$8,550****Travel:** (Line 3)**\$2,374**

Vehicle Use: 5 roundtrips to Exeter (520 mi x 5 = 2,600 mi x \$0.6014/mi = \$1,564

Lodging; \$137 x 5 nights = \$685

Meals: \$25/day x 5 days = \$125

\$F 2,374

Meeting attendance: *(be specific. anticipated travel to meetings such as COC meetings, professional society meetings)*

\$G 0

Subtotal 3 Line 3 subtotal**\$2,374****Subcontracts: Elizabeth Fichtner** (Line 4)**\$7,893****Collaborator A: Elizabeth Fichtner**

\$H 7,893

Subtotal 4 Line 4 subtotal**\$7,893****UCR Total** (Line 5)**\$19,211****UCR Overhead on \$19,211 @ 11% IDC** (Line 6)**\$2,113****(Total to primary PI – Carol Lovatt)** (Line 7)**\$27,104****TOTAL BUDGET REQUEST** Line 4+Line**\$29,217**

PRIMARY PI SIGNATURE PAGE: UNIVERSITY OF CALIFORNIA



Originator's Signature


10-26-2021
Date

DocuSigned by:


039098F4C6224D6
DocuSigned by:
Department Chair/County Director

10/27/2021 | 11:36 AM PDT

Date

DocuSigned by:


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Liaison Officer

10/27/2021 | 12:02 PM PDT

Date

SUBCONTRACT BUDGET REQUEST: (Elizabeth Fichtner)

Budget Year: 2022

Funding Source: COC

Labor:	(Line 1)	\$6242.93
Salary (<i>Junior Specialist at 9% FTE</i>)		\$4494.55
Benefits (38.9%)		\$1748.38
Sub 1		\$6242.93
Supplies, Equipment:	(Line 2)	\$200.00
Supplies: (<i>be specific. general field supplies (flagging tape, pruners, buckets, gloves. etc)</i>)		\$200
Sub 2		\$6442.93
Travel:	(Line 3)	\$667.80
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
Sub 3	(Line 4)	\$7,110.73
UCD/ANR/UCR Overhead @ 11%	(Line 5)	\$782.18
Sub 4 (Total Subcontract)	(Line 6)	\$7,892.91
		<i>(Add Line 6 to primary PI budget in subcontract section 'H' and 'I')</i>

Secondary PI/Collaborator SIGNATURE PAGE: UC ANR

Karmjot Randhawa

10/6/2021

Originator's Signature

Date

**Karmjot
Randhawa**

Digitally signed by Karmjot
Randhawa
Date: 2021.10.06 15:01:36 -07'00'

Department Chair/County Director Date

Karmjot Randhawa

10/6/2021

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 (hedging) 28 days after full bloom (May 30, 2018, May 31, 2019, and June 2, 2020) to one side of 'Manzanillo' olive trees and then the other side annually or every other year on the annual on-tree bloom estimate as the average sum of the east and west sides of each tree, average total yield and average yield of commercially valuable size fruit of packing carton sizes medium+large and calculated as an alternate bearing index^z for the 2-year periods of 2019+2020 and 2020+2021. In 2019 and 2021, NAA and pruning treatments were not applied to other side of the tree and will be applied in 2022. The cytokinin-PGR treatment was applied to the full canopy in February 2021 prior to bud break to increase flowering and yield and again in July 2021 prior to summer vegetative shoot growth to increase summer vegetative shoot growth, fruit size and return bloom in 2022.

Treatment ^y	2019				2020				2021				2019+2020 ABI				2020+2021 ABI				
	Bloom sum (east+ west)	Total yield (kg/tree)	M+L (kg/tree)	Bloom sum (east+ west)	Total yield (kg/tree)	M+L (kg/tree)	Bloom sum (east+ west)	Total yield (kg/tree)	Bloom sum (east+ west)	Total yield (kg/tree)	M+L (kg/tree)	Bloom sum (east+ west)	Total yield (kg/tree)	Bloom sum (east+ west)	Total yield (kg/tree)	M+L (kg/tree)	Bloom sum (east+ west)	Total yield (kg/tree)	Bloom sum (east+ west)	Total yield (kg/tree)	M+L (kg/tree)
1 OFF-crop control	3.1 b ^x	135 d	48 a	4.9 a	79 a	34 a	2.2 c	48 c	34 a	0.42 bc	0.25 d	0.23 c	0.51 a	0.52 c	0.41 b						
2 No treatment	3.9 b	156 bcd	36 abc	3.5 bc	29 b	18 abc	4.5 ab	70 bc	42 a	0.26 c	0.71 b	0.46 bc	0.32 a	0.70 abc	0.67 a						
3 No treatment	3.5 b	142 cd	44 ab	4.4 ab	60 a	29 ab	3.3 bc	49 c	34 a	0.29 c	0.51 c	0.37 c	0.43 a	0.63 bc	0.59 ab						
4 ON-crop control	5.4 a	211 a	19 c	1.5 e	10 b	7 c	5.8 a	115 a	48 a	0.63 a	0.94 a	0.80 a	0.64 a	0.88 a	0.81 a						
5 NAA-West side of tree	4.9 a	180 b	55 a	2.6 cd	24 b	16 bc	5.6 a	108 a	49 a	0.44 abc	0.87 ab	0.70 a	0.47 a	0.82 ab	0.73 a						
6 Pruned-West side of tree	4.9 a	161 bc	23 bc	1.6 de	20 b	16 bc	3.9 b	85 ab	45 a	0.50 ab	0.80 ab	0.61 ab	0.41 a	0.72 abc	0.68 a						

^y P-value <0.0001 <0.0001 0.0138 <0.0001 <0.0001 0.0257 <0.0001 0.0004 0.3238 0.0038 <0.0001 <0.0001 0.1561 0.0311 0.0437

^z Alternate bearing Index (ABI) = year 1 parameter minus year 2 parameter (as an absolute number) divided by the sum of the year 1 + year 2 parameter; parameters are average bloom estimate as sum of east and west side of the trees, total yield per tree, and yield of medium+large size fruit per tree.

^x Mean values within a vertical column followed by different letters are significantly different at the specified P level by Fisher's Protected LSD.

^y All trees were topped on July 7, 2017, May 30, 2018, May 31, 2019, and June 1, 2020. All trees were skirted on July 1, 2020.

Certificate Of Completion

Envelope Id: FAA5498ED07145E4B5FF7FFBCEA376E9	Status: Completed
Subject: Please DocuSign: Fichtner Lovatt 2022 COC Proposal_Final_10-26-2021.pdf	
Source Envelope:	
Document Pages: 11	Signatures: 2
Certificate Pages: 2	Initials: 0
AutoNav: Enabled	Envelope Originator:
Enveloped Stamping: Enabled	Mariam Plowman
Time Zone: (UTC-08:00) Pacific Time (US & Canada)	100 Phoenix Dr.Suite 111
	Lansing, MI 48108
	mariam.plowman@ucr.edu
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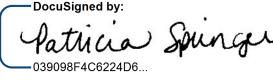
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10/27/2021 11:03:47 AM	mariam.plowman@ucr.edu	

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Patricia Springer
 patricia.springer@ucr.edu
 Professor and Chair
 University of California, Riverside
 Security Level: Email, Account Authentication (None)

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 victoria.sissac@ucr.edu
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Editor Delivery Events	Status	Timestamp
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Intermediary Delivery Events	Status	Timestamp
Certified Delivery Events	Status	Timestamp
Carbon Copy Events	Status	Timestamp

Carol J Lovatt
 carol.lovatt@ucr.edu
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Carbon Copy Events	Status	Timestamp
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Victoria Sissac victoria.sissac@ucr.edu Security Level: Email, Account Authentication (None) Electronic Record and Signature Disclosure: Not Offered via DocuSign	COPIED	Sent: 10/27/2021 12:02:03 PM

Witness Events	Signature	Timestamp
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Notary Events	Signature	Timestamp
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Envelope Summary Events	Status	Timestamps
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Completed	Security Checked	10/27/2021 12:02:03 PM

Payment Events	Status	Timestamps
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Workgroup/Department: Olive / Plant Sciences, UC Davis

Project Year : April 1, 2022 – March 31, 2023. Anticipated Duration of Project: 1 year (UC Davis Sponsored Programs Proposal # 22-1643)

Project Title:

Characterization of olive fruit abscission zone in response to timed ethylene applications and as a function of accumulated heat unit and fruit removal force

Project Leaders:

Dr. Georgia Drakakaki: Professor, Department of Plant Sciences, 210 Asmundson Hall, Mail Stop III, UC Davis, 1 Shields Ave., Davis CA 95616,

Dr. Louise Ferguson: Extension Specialist, Department of Plant Sciences, 2037 Wickson Hall, Mail Stop II, UC Davis, 1 Shields Ave., Davis CA 95616

L.Ferguson@ucdavis.edu

[559-737-3061](tel:559-737-3061)

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

Cooperators:

Dr. Minmin Wang: postdoc, UC Davis

Emily Santos: Assistant Specialist, UC Davis

Dr Judy Jernstedt: Professor, UC Davis

Problem and Significance

Erratic results of ethylene application:

For the non-climacteric table olive, preharvest ethylene applications to decrease fruit removal force and increase mechanical harvesting efficiency has not resulted in consistent results. Goldental-Cohen et al. (2017) demonstrated that applying ethylene coupled with ascorbate. on individual branches of olive trees in small trials, could induce fruit loosening without significant leaf loss. Applying the method of Goldental-Cohen et al. (2017) on the whole tree scale, ethylene and ascorbate sprays did not produce similar results (Ferguson and Fichtner, 2018). Thus, more research is necessary to dissect the effect of ethylene application on olive fruit abscission and removal force in order to optimize mechanical harvesting.

Fruit removal force is correlated with both harvest efficiency and growing degree days:

In September 2021, we applied ethylene on three preharvest dates based on growing degree days and recorded the harvest efficiency of each group. We observed a correlation between fruit removal force (FRF) and harvest efficiency in our 2021 trial (**Figure 1**), and this relationship was

also reported in mechanical harvest of table olives in Israel in 2011 (Zipori et al., 2014). Both results suggest that a low fruit removal force is key to high harvest efficiency.

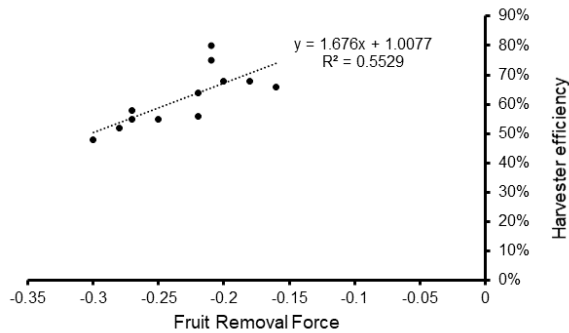


Figure 1. Correlation between fruit removal force and harvester efficiency. Scatter plot shows data of 2021 collected from both Nickels and Burreson Orchards.

The developmental decrease in fruit removal force during the harvest season has been consistently observed in both table olives and oil olives across the literature, with premature olives showing a FRF over 500 g and mature olives near harvest showing fruit removal force around 200 g (Blanco-Roldan et al., 2009; Zipori et al., 2014; Alowaiesh et al., 2016). The quantitatively consistent FRF across locations and years suggests that FRF is a reliable and predictable indicator of olive fruit maturation. Growing Degree Days (GDD) has been widely used to predict growth and harvest timing for other tree crops, for example in pistachio (https://ucanr-igis.shinyapps.io/pist_gdd/, Zhang et al., 2021). If developmental FRF changes could be predicted by GDD accumulation, it could then be used to schedule ethylene applications for maximum effect.

Microscopy-based analyses suggested that whole-tree scale ethylene application induces anatomical changes at the fruit abscission zone:

Cellular level changes at fruit abscission zone were observed after whole tree-scale ethylene application, suggesting that the ethylene treatment effectively triggered cellular changes related to fruit loosening. Though fruit removal force did not show significant difference between ethylene treated and untreated groups, both cell layer detachment and lignification of fruit abscission zone were clearly observed in one treatment group (**Figure 2, see FAZ on 9/16**). Different from Goldental-Cohen et al. (2017) whose ethylene treatment was limited to the small scale on individual fruit branches, our cellular evidence was obtained from whole-tree ethylene application in 2021, providing evidences for immediate application potential of the ethylene treatment in the orchard.

The discrepancy between insignificant fruit removal force decreases and significant cellular changes in ethylene treated groups compared to control, could be explained by the fact that the accumulated cellular changes were not yet translated into sufficient decreased fruit removal force on the day of our harvest (Sept 22nd, 2021). Therefore, understanding the molecular and cellular mechanisms of non-climacteric fruit in response to ethylene application will help in adjusting the timing of ethylene application and harvest in order to reach the desired result.

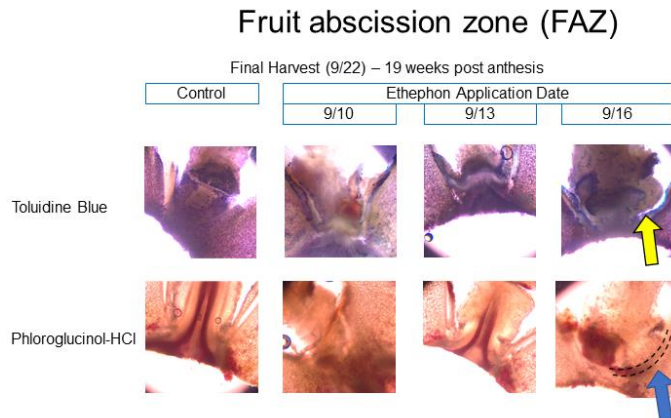


Figure 2. Ethephon treatment of one date induced changes at the fruit abscission zone of olive. Samples were collected on the day of harvest at Nickels Orchard. Toluidine Blue staining is for general cell layer structure, and yellow arrow indicates cell layer detachment. Phloroglucinol-HCl staining indicates lignification of cells, and the blue arrow and dashed line indicates lignification at fruit abscission zone.

Determine non-climacteric fruit ethylene response window in olives:

Unlike climacteric fruits, the ethylene response of non-climacteric fruit is not heavily studied, even though they also produce low amount of ethylene during maturation and ripening. Lots of “black boxes” are in the non-climacteric fruit maturation pathways at both molecular and cellular biology levels (Cherian et al., 2014). The hydrolytic enzyme β -1,4-endoglucanase and polygalacturonase families were the two key players differentially regulated at the fruit abscission zone in immature peach fruitlet, after ethylene accumulated (Ruperti et al., 1998; Bonghi et al., 2000), and their roles in cell wall remodeling of citrus fruit abscission were also investigated (Merelo et al., 2017). These two family of genes were also found differentially regulated in fruit and leaf abscission zones in olive fruits, under a study of small scale ethephon treatment (Goldental-Cohen et al., 2017). In a separate study, changes of different pectin homogalacturonans (methylesterified and demethylesterified) were investigated in the abscission process of a naturally high-abscission variety (*Olea europaea* L. cultivar ‘Picual’) (Parra et al., 2020). We will perform immunolocalization studies of key pectin homogalacturonan polysaccharides, in order to understand their role in cell wall structural changes during ethylene induced fruit abscission in olives. Coupling with transcriptome analyses, our structural analyses will reveal the cellular and molecular responses of successful ethylene triggered maturation in non-climacteric fruit. The cellular and molecular information of successful treatment will further help to determine the ethylene application window for many other non-climacteric fruits of specialty crops.

2022 Objectives: (April 1st – October 31st 2022)

Evaluate olive fruit (*Olea europaea* L. cv. ‘Manzanilla’) growth as a function of accumulated degree days (DD) after full bloom above 59°F (15°C) to determine:

1. Predict when fruit removal force starts to decline, based on 2021 records.
2. At what GDD with corresponding FRF is ethephon most effective.

3. Demonstrate when ethephon applied based on GDD accumulation best increases trunk shaking harvester efficiency.
4. Identify the time window of ethylene application based on FRF prediction with molecular and cellular biology evidence and markers.

Experimental Plan: Field Studies:

The experiment will be conducted at the Nickels Soils Laboratory with moderate density (202 tree/acre) orchard in Colusa County:

- a. Three treatments + three matching controls, four replications, three rows wide @ 5 trees/row for treated and control:
- b. Total 180 treated and 180 controls: 360 trees total

Temperature Logging and Growing Degree Day (GDD) Accumulation Calculation

A data logger* to measure temperature accumulation will be installed onsite to log Growing Degree Day (GDD) accumulation.

*already purchased

At full bloom log daily temperature to calculate GDD accumulation as follows: ($15^{\circ}\text{C} / 59^{\circ}\text{F}$ as Tbase)

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

Fruit Growth Monitoring)

When olives are ~ 1 cm in length, 25 olives per treated and control treatment replications will be collected weekly from the central treatment row:

- Average size by volume (growth) will be determined by water displacement
 - o 3 treatments + matching control: 6 X 4 replications X 10 olives = 240 olives weekly

Fruit Removal Force (FRF) Measurements;

Based on 2021 data when GDD accumulation reaches 2000, fruit removal force (FRF) will be tested on 10 olives/row in the central row of the treated and matching control replications at 100 GDD intervals (approximately a 3-day interval)

- o 3 treatments + matching control: 8 X 4 replications X 10 fruits = 240 olive fruits weekly

Ethephon Treatment:

Ethephon spray will be applied at three successive intervals:

Treatment 1: when predicted FRF is 400 g or less

Treatment 2: when predicted FRF is 200 g or less

Treatment 3: when predicted FRF is 100 g or less, or one week after Treatment 2 whichever comes first.

Ethephon will be sprayed to drip @ 100 GPA rate:

1. 1500 PPM Ethephon 0.25% surfactant
2. Water control and 0.25% surfactant

Harvesting:

Harvest will be done with a trunk shaking harvester or the UC Experimental Harvester; depending upon the ability to obtain the first or support the transport costs of the latter. The harvest date will be targeted at one week after Date 3 with a two week floating range to accommodate the availability of the harvester.

At harvest, the mechanically harvested weight of the central 3 trees of the treated 5 tree sets and the matching control will be combined, weighed and combined into one sample for grading and determination of price per ton.

- o 3 treatments + matching control: 8 X 4 replications = 24 grading samples.

These same 3 trees will be hand gleaned after harvest and fruit weighed but not graded.

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

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

All the additional trees in the plot will be mechanically harvested, but not hand gleaned, to obtain a more representative effect pf ethylene application on yield.

Statistical analysis

An Analysis of Variance (ANOVA) with an LSD means separation test will be used to compare:

Fruit removal force of treated and control trees

Harvester efficiency of treated and control trees

Yield, quality and price per ton of treated and control trees

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

Experimental Plan: Microscopy-Based Abscission Zone Examination:

Sample Collection 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). Based on our 2021 results, only the fruit abscission zone (FAZ) that attaches the fruit to the peduncle is the major player in both control and ethylene treated groups. The fruit AZs sampled for anatomical analysis will be excised by hand to a size of approximately 1 cm² 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 and microscopy-based analyses

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 fuchsin for suberin and lignin as previously described (Wilkop et al., 2019; Ruben Parra & Maria C. Gomez-Jimenez 2020). 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 polysaccharides, 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 dye staining anatomical data obtained from microscopy.

Gene expression analysis

Segments at two selected stages under ethephon treatment and control will be subjected to 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 in field treatments.

References:

- Alowaiesh, B., Singh, Z., and Kailis, S.G.** (2016). Harvesting time influences fruit removal force, moisture, oil content, free fatty acids and peroxide in the oil of Frantoio and Manzanilla olive cultivars. *Aust. J. Crop Sci.* **10**: 1662–1668.
- Blanco-Roldan, G.L., Gil-Ribes, J.A., Kouraba, K., and Castro-Garcia, S.** (2009). Effects of trunk shaker duration and repetitions on removal efficiency for the harvesting of oil olives. *Appl. Eng. Agric.* **25**: 329–334.
- Bonghi, C., Tonutti, P., and Ramina, A.** (2000). Biochemical and molecular aspects of fruitlet abscission. *Plant Growth Regul.* **31**: 35–42.
- Cherian, S., Figueroa, C.R., and Nair, H.** (2014). “Movers and shakers” in the regulation of fruit ripening: A cross-dissection of climacteric versus non-climacteric fruit. *J. Exp. Bot.* **65**: 4705–4722.
- Ferguson, L. and Fichtner, E.J.** (2018). California Olive Committee Final Report: Investigating anti-oxidant-amendments to decrease the leaf abscission with ethephon applications.
- Goldental-Cohen, S. et al.** (2017). Ethephon induced oxidative stress in the olive leaf abscission zone enables development of a selective abscission compound. *BMC Plant Biol.* **17**: 1–17.
- Merelo, P., Agustí, J., Arbona, V., Costa, M.L., Estornell, L.H., Gómez-Cadenas, A., Coimbra, S., Gómez, M.D., Pérez-Amador, M.A., Domingo, C., Talón, M., and Tadeo, F.R.** (2017). Cell wall remodeling in abscission zone cells during ethylene-promoted fruit abscission in citrus. *Front. Plant Sci.* **8**.
- Parra, R., Paredes, M.A., Labrador, J., Nunes, C., Coimbra, M.A., Fernandez-Garcia, N., Olmos, E., Gallardo, M., and Gomez-Jimenez, M.C.** (2020). Cell wall composition and ultrastructural immunolocalization of pectin and arabinogalactan protein during *Olea europaea* L. fruit abscission. *Plant Cell Physiol.* **61**: 814–825.
- Ruperti, B., Bonghi, C., Tonutti, P., and Ramina, A.** (1998). Ethylene biosynthesis in peach fruitlet abscission. *Plant, Cell Environ.* **21**: 731–737.
- Wilkop, T., Pattathil, S., Ren, G., Davis, D.J., Bao, W., Duan, D., Peralta, A.G., Domozych, D.S., Hahn, M.G., and Drakakaki, G.** (2019). A hybrid approach enabling large-scale glycomic analysis of post-golgi vesicles reveals a transport route for polysaccharides. *Plant Cell* **31**: 627–644.
- Zhang, L., Laca, E., Allan, C.J., Mahvelati, N.M., and Ferguson, L.** (2021). Nonlinear model selection for fruit and kernel development as a function of heat in pistachio. *HortScience* **56**: 769–779.
- Zipori, I., Dag, A., Tugendhaft, Y., and Birger, R.** (2014). Mechanical harvesting of table olives: Harvest efficiency and fruit quality. *HortScience* **49**: 55–58.

BUDGET REQUEST: 2022-2023

Budget Year: 2022-2023

Funding Source: COC

Data Collection: \$62,900

Postdoc level III with 3-year experience at 50% with starting base of \$64,927 .

Postdoc: Minmin Wang

Assistant specialist Step II at 25% with starting base of \$59,534

Asst. Specialist: Emily Santos

Two undergraduate students \$3200 (\$1600 x 2).

Benefits rates are calculated using the UC Davis Composite Benefits rates. Benefits for the Postdoc are calculated at 19.5% for the period 04/01/2022 – 06/30/2022, and at 20.1% for period 07/01/2022 – 03/31/2023. Benefits for the Assistant Specialist are calculated at 38.3% for the period 04/01/2022 – 06/30/2022, and at 39.4% for the period 07/01/2022-03/31/2023. Benefits for the Student Assistants are calculated at 1.6% for the entire project period.

The employees will collect samples for analysis and perform fixation, dehydration embedding sectioning, confocal microscopy, polysaccharide and RNA-seq analysis. The employees will be assisting in report and manuscript preparation.

Sub 1 \$62,900

Travel: \$3,340

25% of UC Fleet Services for a truck @ \$284/month and average 1000 miles per month for 4 months + \$50.00/month for gas

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

Sub 2. \$3,340

Supplies, Equipment and service charges: \$37,500

Supplies: Laboratory supplies (dyes, antibodies against polysaccharides, fixation and embedding reagents, imaging supplies, nucleic acid and polysaccharide isolation reagents) \$17,000

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 \$16,000

Harvest Cost: Rental of the harvester @ \$4500 \$4,500

Sub 3 **\$37,500**

Indirect Costs: **\$11,411**

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

Sub 4. **\$11,411**

TOTAL BUDGET REQUEST **\$115,151**

Scope of Work

Emily Santos and Minmin Wang:

Collecting plant samples and analyzing the data.

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. Sample analysis at a cellular, biochemical and molecular level will be performed by Minmin Wang as described in the following section.

Dr. Louise Ferguson will coordinate securing the experimental orchards, coordinate spraying the treatments, concluding the mechanical harvesting and coordinate the evaluation of fruit removal force, harvester efficiency and leaf drop

Drs. Georgia Drakakaki and 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, polysaccharide analysis, RNA-seq, analyzing the data, and writing the final report.

Approved by:

UC Davis Sponsored Programs Proposal # 22-1643

Title: Characterization of olive fruit abscission zone in response to timed ethylene applications and as a function of accumulated heat unit and fruit removal force

Sponsor: California Olive Committee

Approved

Proposal Deadline: 11/5/2021

Contracts and Grants Analyst – Proposal Team

Office of Research, Sponsored Programs

University of California, Davis

UNIVERSITY OF CALIFORNIA DAVIS



11-4-2021

Originator's Signature

Date

Agricultural Experiment
Station

Department Chair

Date

Liaison 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

Ken Shackel, Professor/Pomologist in Plant Sciences, University of California Davis, kshackel@ucdavis.edu

Kosana Suvočarev, Cooperative Extension Specialist in biometeorology, University of California, Davis, ksuvocarev@ucdavis.edu

Co-PIs and Collaborators:

Emily Santos, Assistant Specialist, University of California Davis, eadsantos@ucdavis.edu

Paula Guzman-Delgado, Project Scientist, University of California Davis, pguzmandelgado@ucdavis.edu

Luke Kinney Milliron, UCCE Orchard Systems Advisor, Butte County, lmilliron@ucanr.edu

Louise Ferguson, Cooperative Extension Specialist in Orchard Systems, Department of Plant Sciences, University of California Davis, lferguson@ucdavis.edu (559)-737-3061

Richard Rosecrance, professor of fruit tree physiology and plant mineral nutrition, Chico State University, College of Agriculture, rosecrance@csuchico.edu

Khaled Bali, Irrigation Water Management Specialist, UC Kearney Agricultural Research and Extension Center, kmbali@ucanr.edu

Barbara Blanco-Ulate, Professor in Fruit biology, postharvest physiology and quality, University of California, Davis bblanco@ucdavis.edu

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

Abstract

Precise, grower friendly irrigation management is crucial for the economical and environmental sustainability of olive industry as the water supply uncertainties are increasing through drought risks and environmental regulations. Despite the large amount of information developed internationally about olive irrigation management, very few research has been conducted in California. We propose a multidisciplinary approach for developing irrigation strategies for CA table 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 table 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 maximizing the economical sustainability of olive systems. For this reason, a big research effort has been done 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. Unfortunately, most of this research has been performed in other countries and California table olive growers still lack some essential local research information to implement irrigation precisely in their orchards.

In particular, we identified the following information gaps:

- 1) lack of a locally-developed crop coefficient (K_c) for mature, high density table olive orchards. Irrigation management guidelines suggest the use of a crop coefficient developed in 1989 for flood-irrigated, widely spaced orchards that, in addition, does not consider changes associated with the annual olive phenological cycle.
- 2) lack of a temperature-based phenological model to predict water stress sensitive and tolerant stages of development. Predicting phenological stages of development is crucial to correctly modify irrigation management through the season.
- 3) lack of guidelines on how to use plant-based indicators, such as stem water potential, to characterize desired tree water status levels.

Objectives:

We propose a multidisciplinary approach to:

1. Characterize orchard evapotranspiration (ET) and crop coefficient (K_c) for a mature, well-irrigated, high-yielding, table olive orchard with drip-irrigation and typical California production practices.
2. Define the thermal time (growing degree days) for the different phenological stages of development of olive relevant for irrigation scheduling
3. Develop information on how to use stem water potential to manage water in table olive systems
4. Conduct extension educational and outreach activities for olive producers and other stakeholders

in California

This information is essential for table olive growers in California to improve precision of irrigation management during stress tolerant periods without affecting yield but improving fruit quality and water productivity.

First year achievement and second year proposed activities:

1) Develop updated water use information (ET and Kc)

2021 achievements: We instrumented the selected orchard with an ET station in mid-May 2021. This allowed us to measure real time orchard actual crop evapotranspiration (ETa) and calculate the crop coefficients. We found that the orchard used 19 inches of water from mid-May to the end of September, the crop coefficient varied between 0.8 and 0.5, bi-weekly water use was between 2 and 3 in.

2022 proposed activities: We propose to continue the collection of ET and Kc data. Crop coefficient data needs to be collected over multiple years to be reliable and representative of different hydrological conditions. Year specific conditions, such as crop load or water availability may affect orchard water use and thus crop coefficients. For example, this year was particularly dry and having the comparison with wetter years is important for the reliability of the information developed.

2) Define the thermal time (growing degree days) for the different phenological stages of development of olive relevant for irrigation scheduling

2021 achievements: Biometrical data were collected biweekly to characterize the shoot and fruit phenological stages of development that would need major attention from an irrigation standpoint. We identified three critical times: shoot vegetative growth rate peaks in spring and late summer, high fruit growth rate periods, and pit hardening.

2022 proposed activities: Similarly, to the ET data, also the phenological data would need to be collected at least for another year. Due to the high temperatures during 2021 developmental stages may have been affected and seasonal data collection over multiple years is expected to improve our insights and estimation of phenological development.

3) Develop information on how to use stem water potential to manage water in table olive systems

2021 achievements: During the first year of data collection, stem water potential was monitored weekly, and the irrigation system was modified to reduce water application by 20 and 50% relative to a “Control” treatment, which was the management of our grower collaborator.

We compared the stem water potential values from the monitored orchard (that were between -1.5 and -3 MPa) with a baseline (potential values for fully hydrated trees) recently developed in a parallel project lead by Dr. Shackel. This comparison highlighted that the trees were always (~ 1 MPa) below the baseline; This suggests that trees were under a moderate to mild water stress and that it would be possible to increase tree hydration levels by increasing the volume of water application, particularly during water sensitive stages. It also highlighted the importance to monitor very frequently plant water status to gather information about how to improve water management to target higher yield.

2022 proposed activities: based on these conclusions, we propose this year to test the impact of increasing water application on yield quantity and quality. We also propose to install newly developed sensors (Florapulse) for continuous stem water potential monitoring and calibrate them against the pressure bomb readings. These sensors have been tested successfully in other crops such as almond and can be an important

resource for growers to automate irrigation based on tree water status in the near future.

Expected outcomes:

We expect to develop the following information for growers: 1) crop coefficients and water use of a high density table olive orchard grown in typical CA conditions. 2) temperature-based prediction of table olive phenological stage of development 3) calibration of automated plant water status monitoring sensors for table olive, 4) guidelines on how to ensure optimal tree hydration levels based on stem water potential measurement for table olives over the season. This information will have a potential to increase the competitiveness of California olive industry through better irrigation resulting in increased orchard yield and quality, increased water and energy productivity, reduced inputs 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 due to drought risks and environmental regulations.

Extension and outreach:

We will develop an extension publication to outreach to growers and stakeholder the information developed and organize one field day to demonstrate the ET data collection and the use of the pressure chamber and monitoring sensors installed in the field.

RESEARCH GRANT PROPOSAL BUDGET WORKSHEET

Contract administrator: Dana Chavez

Email:

ITEM	2021-2022
Salaries (30% Assistant specialist)	\$16,679
Employee benefits	\$9,096
Undergrad student (1 day a week for 8 months)	\$3,840
Flora pulse sensors (3 sensors, \$1200 each)	\$3,600
Travel (4 trips/month per 8 months, and one per month for 4 months, \$61 of truck rental and 0.27 per mile of gas)	\$4,276.08
Miscellaneous (lab material for phenological characterization, irrigation supply and field supply for harvest and data collection)	\$3,000
Publication fees, printing of extension material and organization of field day	\$1,500
Total (without overhead)	\$41,991
Total with overhead (with 11% overhead)	\$46,610.10

Originator's signature (PI):



Date: 10/29/2020

Authorized signature:

Date:

CALIFORNIA OLIVE COMMITTEE
PROJECT PLAN/RESEARCH GRANT PROPOSAL

Workgroup/Department: School of Engineering – Mechanical Engineering

Project Year: Anticipated Period of Performance: 01/1/2022 – 12/31/2022

Project Title: Combining limb shaking and canopy shaking for harvesting mature olive trees

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

Co-PI: Louise Ferguson, CE Pomologist, Department of Plant Sciences, UC Davis, Email: lferguson@ucdavis.edu, Phone: (559) 737-3061

Grower Collaborators: Vito DeLeonardis, David Lester

Commodity: _____ Relevant AES/CE Project No.:

Year Initiated: 2022_ Anticipated Duration of Project: one year

Project Summary

This project aims to reduce table olive harvesting costs by developing a cost-effective harvesting system for large mature table olive trees. The proposed project is the continuation of the project that was funded by the COC last year. We propose to develop an efficient fruit removal system for harvesting of table olives from mature trees. The goal is to build the fruit removal system as an attachment that can be installed on a small excavator to reduce the cost and can be built easily in local fabrication shops. Our goal is to be able to remove 90 percent of fruits with little damage to the fruit. The proposed machine will combine a limb shaker and a canopy contact shaker to optimize the shaking energy for fruit removal.

Problems and Significance:

Despite the worldwide increase in demand for table olives, the industry is declining due to high production costs, primarily the manual labor of pruning and harvesting. Most growers are replacing table olive trees with more profitable, mechanically pruned and harvested nut crops. Harvesting is the major cost of production for table olives. With the increase in minimum wages in California next year, the harvest cost will be even higher.

A mechanical harvesting system has three main components: 1) fruit removal mechanism, 2) catch frame, and 3) fruit cleaning and transportation. The biggest challenge in developing a mechanical harvesting system for table olives is developing a fruit removal system that removes the fruits efficiently with no or minimal damage to the fruit and tree.

Some olive growers are using the trunk shakers designed to harvest nuts with limited success. The willowy olive architecture prevents effective transmission of the vibrational energy from the trunk to the small vertical peripheral branches where the fruits are located. The horticulturally mature but physiologically immature olives high fruit detachment force (~ .4 kg or ~ 1.0 lb) to low fruit weight (~ 3-5 grams or 0.2 ounce) ratio is even less suited to trunk shaking.

Most mature olive orchards in California have large, irregular trunks that are too large and irregular to be effectively grasped by a shaker head. Other factors also need to be addressed when developing a mechanical harvesting system; for example, mechanical harvesting of the most popular ‘Manzanillo’ cultivar bruises the fruits resulting enzymatic activity producing browning.

Ehsani’s group at UC Merced, through a grant from the COC, designed a light canopy contact shaker-based fruit removal system that can accommodate larger trees. This system has shown promising results. 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. As a part of the COC funded project, a simultaneous combination of trunk and canopy shaker technologies was tested in 2020. The combined shaking technologies demonstrated a higher harvest efficiency compared to using either alone.

This canopy shaker shown in figure 1 was used in combination with a trunk shaker to harvest

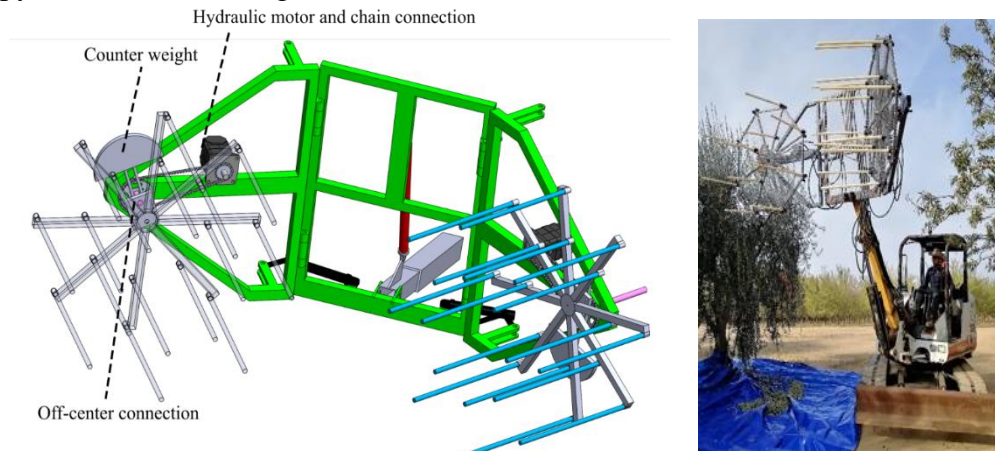


Figure 1. UC Merced fruit removal canopy shaking head

olive trees in Nickels Soils Laboratory in 2020. Figure 2 shows the average harvest efficiency of all three shaking methods. This figure shows combining the shaker technologies improved harvest efficiency by 41% and 19% compared to the canopy shaker and trunk shaker alone, respectively.

In the 2021 project, the COC Research Committee suggested we focus on mature trees. We proposed to develop and test a large canopy shaker and test its efficiency in combination with a trunk shaker at Mr. Vito Deleonardis’s olive orchard with mature trees. We also combined this experiment with a pruning experiment.

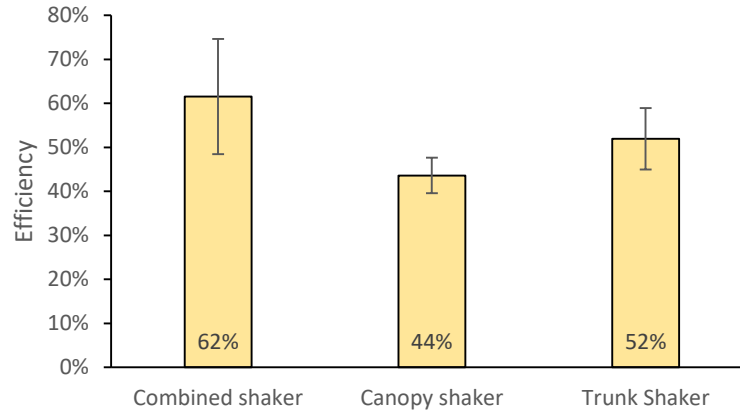


Figure 2 Comparing harvest efficiency of all three methods.

The new canopy shaker was built in Ehsani’s Lab (Fig. 3). The new canopy shaker head has a rectangular shape with a height of 8 ft and a width of 10 ft. The shaker head has a total of 37 nylon rods. These nylon rods are the contact point between the canopy shaker and the tree. Each rod is 1” in diameter and 26” long. The shaker head was installed on a Bobcat 337. Figure 4 shows the off-center mechanism used to generate circular oscillatory motion. The canopy shaker was set to a 2” off-center distance, generating an oscillation with a 4” amplitude.



Figure 3. Newly designed canopy shaker built for mature, large olive trees in California.

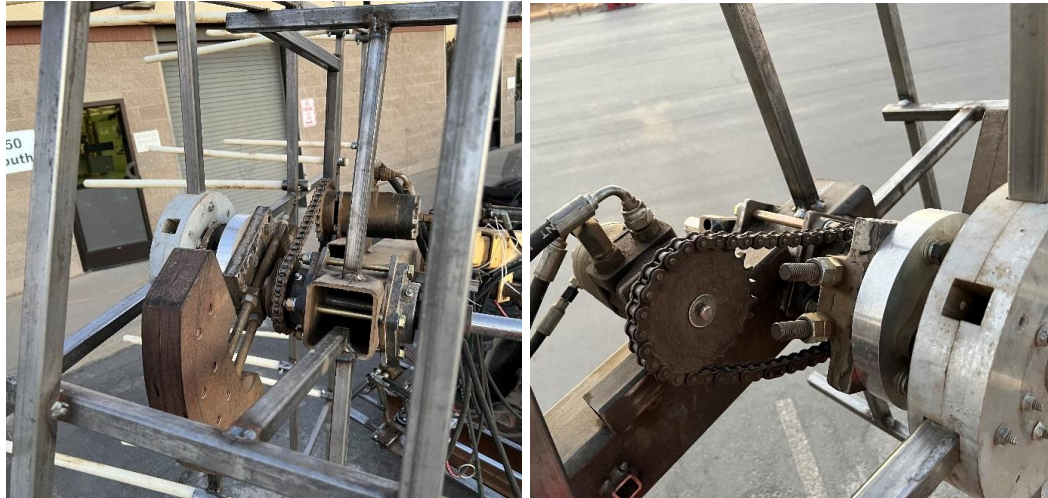


Figure 4. The internal mechanism used to generate circular oscillation movement in the canopy shaker

Upon visiting Mr. Delenoardis’s mature trees, we realized that it is not possible to use a trunk shaker in his olive orchard because the trees had short irregular trunks which prevented using a trunk shaker. Therefore, we decided to use a rope shaker instead of trunk shaker. This shaker machine was tested in the Deleonardis orchard on September 23rd, 2021. The 30-year-old, 20 x 26 spaced sample trees were topped at both 12 and 14 feet in May 2021. Four trees were randomly selected from each height category for this experiment. Tarps were used to collect the mechanically harvested fruit for weighing. Our rope shaking system broke down during the first trial, and we decided to run the machine without the rope shaker. Table 1 shows the results of the field experiments as it shows the overall fruit removal was about 35% on average.

Table 1. Harvest fruit data from each tree.

Tree	Topped height (ft)	Mechanically harvested fruits (lb.)	Manually harvested fruits (lb.)	Total weight	Harvest Efficiency
1	12	53.4	118.4	171.8	31%
2	12	63.6	103.9	167.5	38%
3	12	53.3	104	157.3	34%
4	12	41.2	131	172.2	24%
5	14	83.6	115.4	199	42%
6	14	61.2	95.3	156.5	39%
7	14	60.1	76.3	136.4	44%
8	14	50.1	100.6	150.7	33%

The shaking head was able to remove most of the fruits where it contacted the canopy. The large size of shaking head and lack of ability to move around the canopy to reach a different part of trees were the main reasons for overall low fruit removal efficiency.

Objectives:

Based on the results of the field test from the 2021 harvest season and input from olive growers that observed the canopy shaker performance we made modifications to improve the fruit removal efficiency. Also, the rods, in some cases, damaged the fruit, and \need to be padded to reduce fruit damage.

This study aims to enhance the design of the canopy shaker developed last year, enabling it to reach more of the tree canopy and to build a combined limb and canopy shaker machine specifically for mature table olives trees. The second objective is to study the effect of pruning on harvest efficiency.

Experimental Procedures:

To achieve the objectives, the following tasks are proposed:

Task 1: Design a shaker head with multiple degrees of freedom that enable the operator to reach and shake different parts of a tree. A concept design is shown in figure 5.

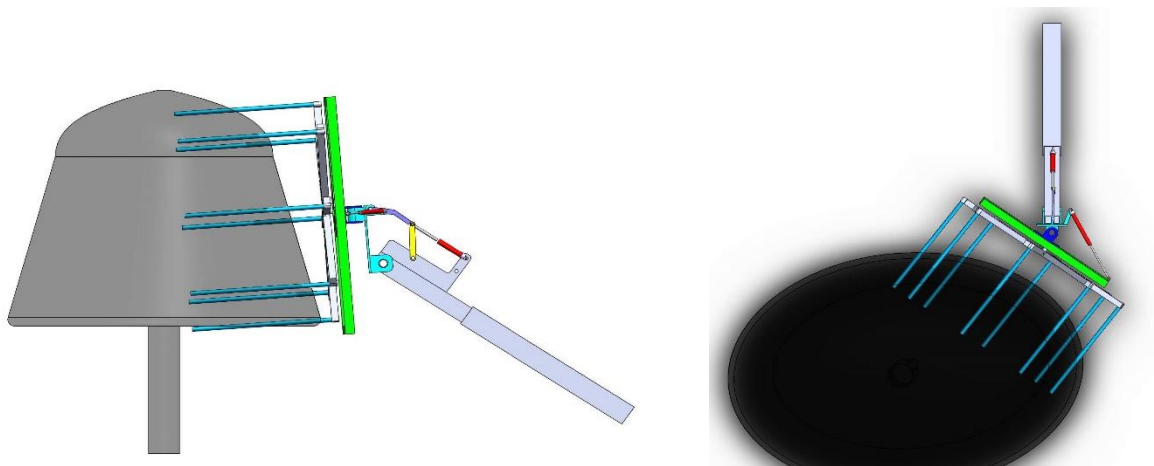


Figure 5. Proposed shaking head with multiple degrees of freedom

Task 2: Design a limb shaker. Due to variability in the shape and location of tree branches combining the canopy shaker with a limb shaker is needed to get maximum fruit removal. We propose to build a limb shaker or buy one if it is available commercially and use it in our project instead of the rope shaker that failed last year.

Task 3: Evaluate the performance of the machine in the field. We plan to conduct a series of field trials with mature olive trees in at least in two locations. The proposed plan of research and data collection will be similar to that proposed last year.

Task 4: Determine whether pruning would increase harvest efficiency or not. Last year we didn't see any clear difference between the fruit removal from topped trees at different heights. We would like to continue that this year to see if the results will be different after one year.

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

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											█	█

BUDGET REQUEST: Reza Ehsani

Budget Year: 2022

Funding Source: COC

Labor:	Line 1
Salary	
One Undergraduate Student Researcher	
20% during Academic Terms and 100% during Summer Term	\$10,140
3% Benefit Rate	\$304
Subtotal 1	Line 1 Subtotal \$10, 444
Supplies:	Line 2
Supplies: Estimates for raw materials for fabrication, hydraulic components, hosing and hydraulic motors, hydraulic valves (\$4,000), consumable shop and welding supplies, supplies for field data collection supplies (\$1,500)	
Subtotal 2	Line 2 subtotal \$5,500
Travel:	Line 3
Vehicle Use: Truck use for two weeks for field trials	\$500
Dr. Ferguson travel charges, for work site and COC meetings	\$0
Subtotal 3	Line 3 subtotal \$0.00
Subaward:	Line 4
Subaward for Dr. Louise Ferguson for helping with pruning experiments and evaluation of fruit quality	\$5,000
Subtotal 4	Line 4 subtotal \$5,000
Total of lines 1 through 4 above	(Line 5) \$31,444
Modified Total Direct Cost	(Line 6) \$31,444
UCD/ANR/UCR Overhead @ 11% IDC on MTDC (Line 6)	(Line 7) \$3,459
Total to Primary PI)	(Line 5 + 7) \$34,902
TOTAL BUDGET REQUEST	\$34,902

PRIMARY PI SIGNATURE PAGE: UNIVERSITY OF CALIFORNIA

Reza J Ehsani

Originator's Signature

11/08/2021

Date

Department Chair/County Director

Date

Liaison Officer

Date

PROJECT PLAN/RESEARCH GRANT PROPOSAL

Project year: 2022

Anticipated Duration of the project: April –November 2022

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

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

Cooperating personnel: Bert Quezada, 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. Some of the sites have been monitored starting in 2001. All traps will be in place by March 24, 2021. The traps will be read and reported by April 1, 2022 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 18, 2022.

BUDGET REQUEST

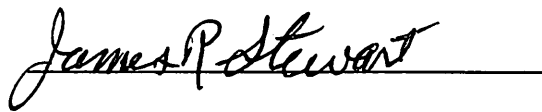
Budget year: April 1, 2022-December 1, 2022

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

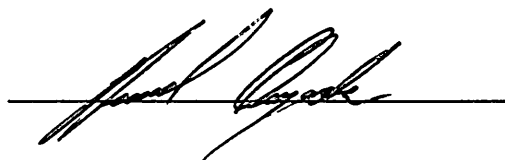
Salaries and benefits:	<u>\$16,500.00</u>
Supplies:	
Traps, bait and pheromone	<u>2,000.00</u>
Travel:	
Mileage to trap sites	<u>3,000.00</u>
Equipment:	<u>0.00</u>
	TOTAL <u>\$22,000.00</u>

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

Total funding from the California Olive Committee would be: \$11,000 *



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.

Ernie's Pest Control

Project Plan/ Research Grant Proposal

Project Year: 2022

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

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 late March, 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 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: 2022

Table with 2 columns: Description, Amount. Rows include: Salaries plus insurance (\$7050), Supplies and Expenses: Trapping Supplies (500), Travel 3080 mi. @ \$.552/mi. (\$1700), Total (\$9250).

Originator's Signature [Handwritten Signature]

Ernie Simpson

***** FOR YOUR INFORMATION *****

FROM: RESEARCH SUBCOMMITTEE

SUBJECT: VALENT PRESENTATION ON ACCEDE

BACKGROUND: Kristina Madden from Valent has prepared a presentation on plant growth regulator, Accede, and its potential use for the California olive industry. Her presentation slides are included in the following pages.

AccedeTM



PLANT GROWTH REGULATOR



Accede™ Plant Growth Regulator



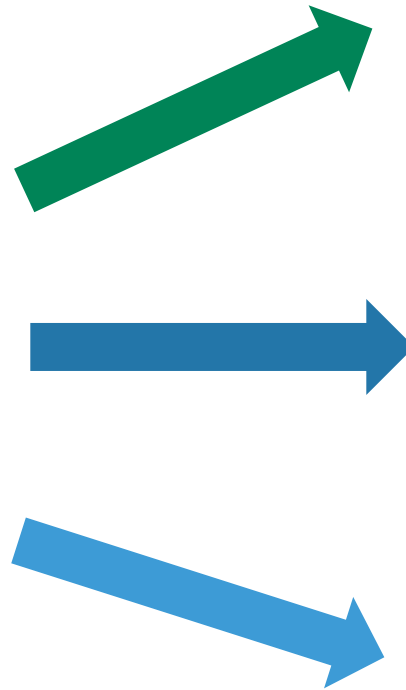
- Accede contains ACC, a naturally occurring non-protein amino acid and is the precursor to ethylene in all plants. Ethylene affects many plant development processes including fruit abscission, fruit coloring and fruit ripening.
- Accede is currently approved for crop load management:
 - First chemical thinning solution for **peaches & nectarines**
 - Later chemical thinning solution for **apples**



Accede™ PGR Benefits



The new crop load management tool for apples, peaches and nectarines



Delivers effective crop load management

Allows for less labor for hand thinning

Increases fruit size

Accede™ PGR Uses



STONE FRUIT

Peach & Nectarine Thinning

- First ever chemical thinning product
- Timing: pink bud to petal fall

Apple Fruit Thinning

- Newest and most consistent product for later apple thinning
- Ideal Target: 15–20mm king fruit



APPLES

Accede™ PGR Specifications



Active Ingredient	1-Aminocyclopropane-1-carboxylic acid (ACC)
Chemical Group	Ethylene Promoter
Formulation	10% SL (15 oz ai per gallon)
Registration	Accede has been federally approved for use on apples, peaches and nectarines.
Chemical Structure	The chemical structure of 1-Aminocyclopropane-1-carboxylic acid (ACC) is shown. It consists of a three-membered cyclopropane ring. One carbon atom of the ring is bonded to both an amino group (-NH ₂) and a carboxylic acid group (-COOH). The carboxylic acid group is drawn with a double bond to an oxygen atom and a single bond to a hydroxyl group (-OH). <chem>NC1CC1C(=O)O</chem>

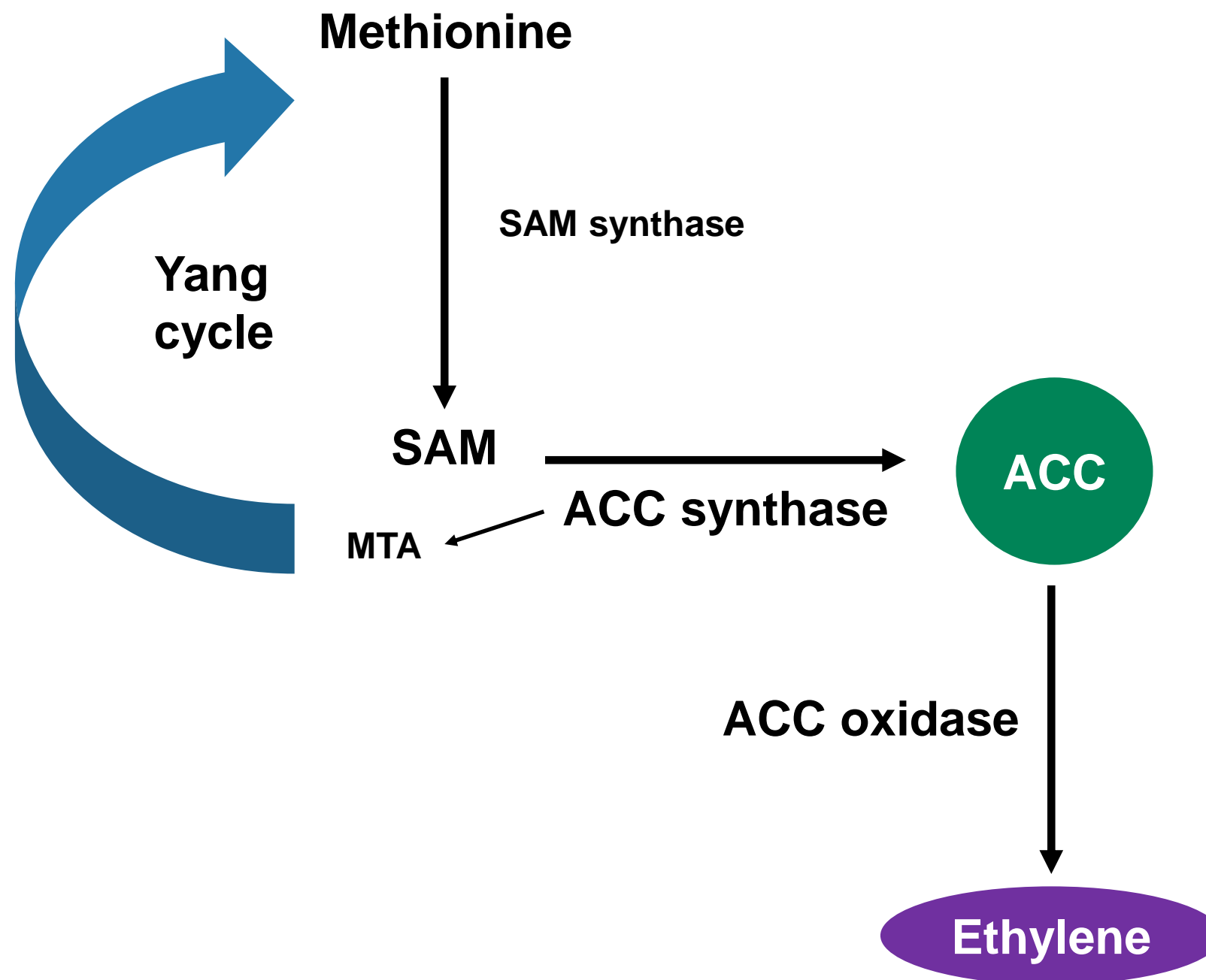
Accede™ PGR Mode of Action



ACC synthesis and metabolism in plants:

- Accede is a liquid formulation of 10% (wt/wt) ACC that is, once taken up by the plant, quickly converted to ethylene using the plants natural biochemical pathways (by ACC oxidase enzyme)
- The ethylene generated after application of Accede stimulates and accelerates flower and fruit drop in stone fruit and apples, reducing the expense of labor needed for hand thinning
 - Ethylene signaling triggers seed abortion and activation of the abscission zone (AZ) at the base of the fruit stem
- Accede does not leave ACC residues (tolerance exempt)

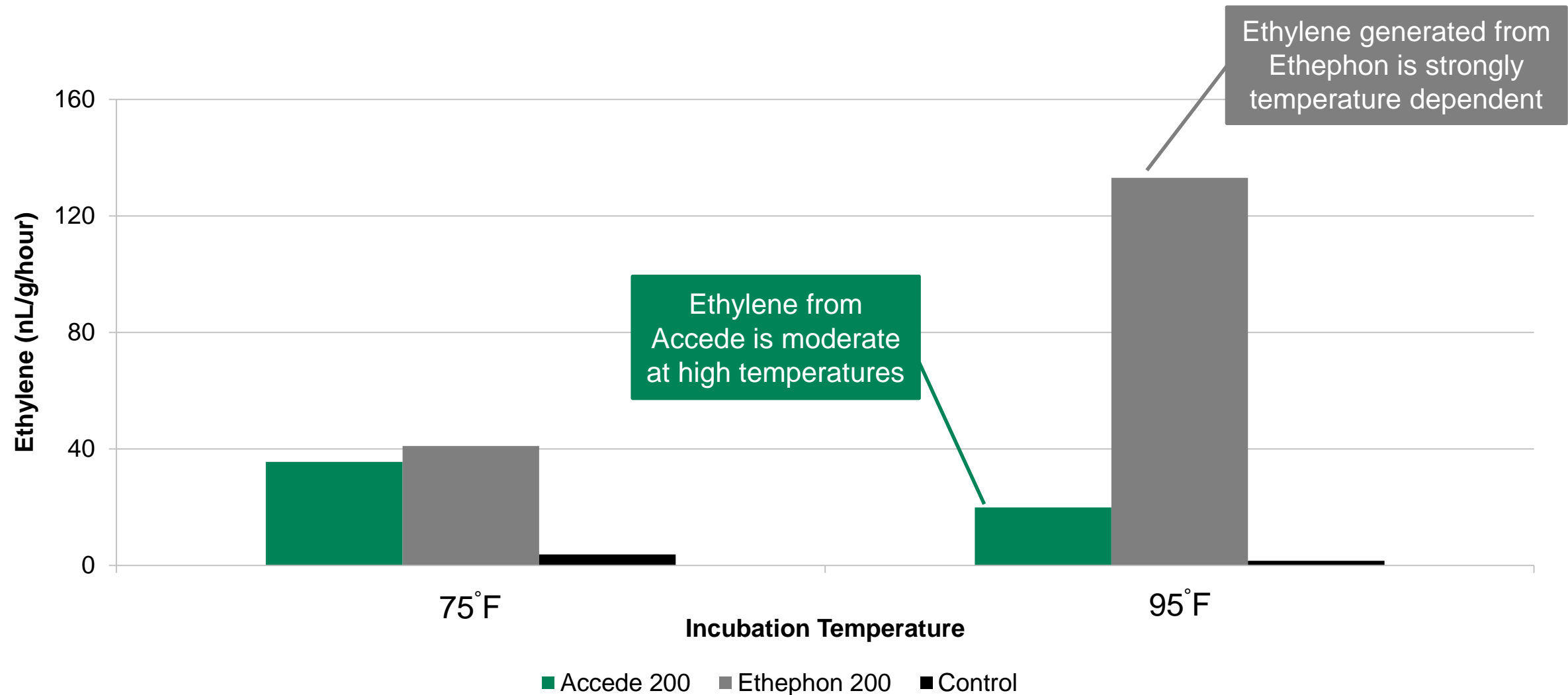
Accede™ PGR Mode of Action



Accede™ PGR vs. Ethephon



Accede is a reliable and consistent fruit thinner



Accede™ PGR: How To Use—Apples



Rate	200 to 400 ppm <ul style="list-style-type: none">• Equivalent to 23–46 fluid ounces of product in 100 gallons of water per acre
Adjuvant	For optimal response, use Accede with a non-ionic surfactant at a rate of 0.125% (v/v) in the spray tank
Timing	<ul style="list-style-type: none">• Accede can be applied in the period from 8 to 25 mm king fruit diameter• Accede is most effective when king fruitlet diameter is 15–20 mm

Accede™ PGR: Use Timing—Apples



Full Bloom



Petal Fall



**5–7 mm
Fruit Diameter**



**8–12 mm
Fruit Diameter**



**14–18 mm
Fruit Diameter**



**20–25 mm
Fruit Diameter**



Accede™ PGR: How To Use—Stone Fruit



Rate	<p>Peaches/Nectarines: 300 to 600 ppm</p> <ul style="list-style-type: none">• Equivalent to 34–69 fluid ounces of product in 100 gallons of water per acre
Adjuvant	<p>For optimal response, use Accede with a non-ionic surfactant at a rate of 0.05% (v/v) in the spray tank</p>
Timing	<ul style="list-style-type: none">• Accede can be applied from the bloom stage through petal fall• Make the first application of Accede from early to full bloom. If necessary, a second application may be made 7 to 10 days later (up to petal fall).• Currently not approved for post bloom applications

Accede™ PGR: Use Timing—Peach & Nectarine



Pink Bud



Early Bloom



Full Bloom



Early Petal Fall



Late Petal Fall



Shuck Split

Single application approach

Two applications approach

1st application

2nd application

Accede is currently not approved for post bloom applications

Accede™ PGR Best Management Practices



- Maintain solution pH between 5 and 8
- Do not apply Accede when frost is expected as overthinning may occur
- If frost occurs during bloom, wait until damage to flowers and buds can be assessed to determine if application of Accede is needed
- Do not apply Accede if rain is expected within 8 hours of application
- Use of Accede may result in minor to moderate leaf yellowing and/or leaf drop. This response has been sporadic in apples and transient in nature.
- Do not apply Accede to injured or stressed plants or fruits (e.g. drought stress, freeze injury, girdled trees, root pruned trees, etc.)
- Do not use overhead cooling or irrigation equipment for at least 8 hours following Accede application
- Store between 45 and 80°F. The product, once opened, should not be stored below 55°F.

Thank You



*****ACTION REQUIRED*****

FROM: COC RESEARCH SUBCOMMITTEE

SUBJECT: APPROVAL OF 2022 BUDGET

RECOMMENDATION: THAT the Subcommittee approve various research projects for 2022.

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 **\$365,585.30** (with no-cost extensions) is proposed based on the submitted projects.

2022 RESEARCH PROPOSAL FOR THE CALIFORNIA OLIVE COMMITTEE

TOPIC	LEADERS	AMOUNT
Management of Foliar Diseases of Olive-A. Olive Knot and B. Evaluation of new fungicides for control of olive leaf spot	J.E. Adaskaveg	\$9,000
Epidemiology and Management of Olive Knot Caused by Pseudomonas Savastanoi pv. Savastanoi	J.E. Adaskaveg	\$21,250
Remotely Sensed Olive Crop Mapping for Regulatory Compliance, Water Resource Management and Decision Support	Land IQ	\$21,100
Managing Alternate Bearing in Olive with PGRs and Pruning	Carol Lovatt Elizabeth Fichtner	\$29,217
Characterization of Olive Fruit Abscission Zone in Response to Timed Ethylene Applications and as a Function of Accumulated Heat Unit and Fruit Removal Force	Georgia Drakakaki Louise Ferguson	\$115,151
Precise Water Management Strategies for Table Olive Orchards in California	Giulia Marino Ken Shackel	\$46,610.10
Combining Limb Shaking and Canopy Shaking for Harvesting Mature Olive Trees	Reza Ehsani Louise Ferguson	\$34,902
Southern San Joaquin Valley Olive Fruit Fly Monitoring	Jim Stewart	\$11,000
Sacramento Valley Olive Fruit Monitory Project	Ernie Simpson	\$9,250
2021 NCE Managing Alternate Bearing in Olives with PGRs and Pruning	Carol Lovatt Elizabeth Fichtner	\$10,892
2021 NCE Characterization of Olive Fruit Abscission Zone in Response to Ethylene Applications and as a Function of Developmental Stage	Georgia Drakakaki	\$25,704
2021 NCE Precise Water Management Strategies for Table Olive Orchards in California	Giulia Marino Louise Ferguson	\$21,721.20
2021 NCE Timing Ethylene Applications as a Function of Heat Unit Accumulation	Louise Ferguson Giulia Marino	\$9,788
Total * budget estimate; actual budget pending on results		\$365,585.30- With NCEs

******ACTION REQUIRED******

FROM: COC RESEARCH SUBCOMMITTEE

SUBJECT: 2022 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.

*****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.