2565 Alluvial Ave. Suite #152, Clovis, California 93611 • P. 559 456-9096 • F. 559 456-9099

AGENDA

California Ripe Olive
Research Subcommittee Meeting
San Joaquin County Ag Commissioner Office
Zoom/Conference Call

AUGUST 10th, 2022
9:00 AM

Join Zoom Meeting:
https://us02web.zoom.us/j/88099916402

Dial-in:
+1669-900-6833
Meeting ID: 880 9991 6402

I. **Call to Order**
   a. Roll Call page 2
   b. Research Subcommittee Chairman's comments
   c. Approval of November 10, 2021 Minutes (action item) page 3

II. **Review of 2021 Research Final Reports** page 11

III. **Presentation of Cost Study** (action item)
   a. Brittney Goodrich-UC Davis page 73

IV. **Discussion and Approval of 2023 Research Priorities** (action item) page 76

V. **Update on CA Specialty Crop Block Grant Projects** page 78

VI. **Introduction of New Olive Researchers** page 79

VII. **Other Business**

VIII. **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

California Olive Committee

Research Subcommittee Meeting
NOVEMBER 10, 2021
10:30 am
Zoom/Conference Call
http://US02web.zoom.us/j/83457081282

MINUTES

I. CALL TO ORDER

A meeting of the Research Subcommittee Meeting was called to order by Chairman Dennis Burreson at 10:32 a.m. and the following members were present:

Members	**Affiliation:**
Carolina BURRESON	Producer
Michael SILVEIRA	Producer
Chris HENDERSON	Producer
Andy WEINRICH	Producer
Vito DELEONARDIS	Producer
Giulio ZAVOLTA	Producer
Pat RICCHIUTI	Producer
Galen PHEIFFER	Producer
Mark HUER	Producer
Dennis BURRESON - Chairman	Handler
John PIERETTI	Handler
Tomas MASANES AUTARD	Handler
Julia TINSLEY	Handler
Jacob PETERS	Handler
STAFF	
Todd SANDERS	California Olive Committee
Elizabeth CARRANZA	California Olive Committee
Elise OLIVER	California Olive Committee
Janette RAMOS	California Olive Committee
GUESTS	
Kathie NOTORO	USDA
Dr. Giulia MARINO	UC Davis
Carol LOVATT	UC ANR
Elizabeth FICHTNER	UC ANR

Minmin WANG	UC Davis
Reza EHSANI	UC Merced
Jim ADASKAVEG	UC Riverside
Georgia DRAKAKAKI	UC Davis
Jim STEWART	Southern San Joaquin Valley Olive Fruit Fly Monitoring
Ernie SIMPSON	Sacramento Valley Olive Fruit Fly Monitoring
Kristina MADDEN	Valent USA
Casey GUDEL	Land IQ
Joel KIMMELSHUE	Land IQ
Mica HEILMAN	Land IQ

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

- **MOVED by RICCHIUTI, duly seconded by C. BURRESON and carried THAT the minutes for July 20, 2021, be approved as presented. (MOTION 11-10-21 #1)**

II. DISCUSSION AND REVIEW OF 2021 PROJECTS

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 Fichtner	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	$64,260	3/11/2021	$38,556	60%	

	Function of Developmental Stage					
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		

III. PRESENTATION OF 2022 PROPOSALS

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 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
Total * budget estimate; actual budget pending on results		**$297,480.10**

IV. PRESENTATION FROM VALENT

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

V. APPROVAL OF 2022 BUDGET

ACTION

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

- **MOVED by SILVEIRA, duly seconded by RICCHIUTI and carried THAT the Research Subcommittee fund Dr. Adaskaveg's two projects, one for $9,000 and $21,250 for a total of $30,250 for Fiscal Year 2022. (MOTION 11-10-21 #2)**

- **MOVED by RICCHIUTI, duly seconded by HEUER and carried THAT the Research Subcommittee fund Dr. Carol Lovatt project for $29,217 for Fiscal Year 2022. (MOTION 11-10-21 #3)**

- **MOVED by HEUER, duly seconded by C. BURRESON and carried THAT the Research Subcommittee fund Dr. Drakakaki project of $115,151 for Fiscal Year 2022. (MOTION 11-10-21 #4)**

- **MOVED by RICCHIUTI, duly seconded by ZAVOLTA and carried THAT the Research Subcommittee fund Dr. Giulia Marino's project of $46,610.10 for Fiscal Year 2022. (MOTION 11-10-21 #5)**

- **MOVED by DELEONARDIS, duly seconded by ZAVOLTA and carried THAT the Research Subcommittee fund Dr. Ehsani's project of $34,902 for Fiscal Year 2022. Only two (2) board members voted nay on the project, Mark Heuer and Pat Ricchiuti. (MOTION 11-10-21 #6)**

- **MOVED by SILVEIRA, duly seconded by RICCHIUTI and carried THAT the Research Subcommittee fund Jim Stewart's project of $11,000 and Ernie Simpson's project of $9,250 for Fiscal Year 2022. (MOTION 11-10-21 #7)**

- **MOVED by SILVEIRA, duly seconded by C. BURRESON and carried THAT the Research Subcommittee approve the contingency Fund of $35,000 for Fiscal Year 2022. (MOTION 11-10-21 #8)**

VI. APPROVAL OF AUTHORITY TO THE EXCUTIVE DIRECTOR AND CHAIRMAN TO APPROVE NO-COST EXTENSIONS

ACTION

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.

- **MOVED by HEUER, duly seconded by DELEONARDIS and carried THAT the Research Subcommittee grant authority to the Executive Director in conjunction with the Chairman to approve requests for no-cost extensions (MOTION 11-10-21 #9)**

VII. APPROVAL OF AUTHORITY TO THE EXECUTIVE DIRECTOR AND CHAIRMAN FOR INTER-ITEM TRANSFER OF THE RESEARCH SUBCOMMITTEE BUDGET

ACTION

- **MOVED by HEUER, duly seconded by D. BURRESON and carried THAT the Research Subcommittee grant authority to the Executive Director and Chairman for inter-item transfers of the Research Budget. (MOTION 11-10-21 #10)**

VIII. OTHER BUSINESS

NONE

IX. ADJOURNMENT

Chairman Dennis BURRESON adjourned the Research Subcommittee meeting at 1:00 p.m.

Todd W. Sanders
Executive Director
California Olive Committee

SUMMARY OF MOTIONS FOR NOVEMBE 10, 2021

<u>Motion 11-10-2021 #1</u> **APPROVED**

MOVED by RICCHIUTI, duly seconded by C. BURRESON and carried THAT the minutes for July 20, 2021, be approved as presented.

<u>Motion 11-10-2021 #2</u> **APPROVED**

MOVED by SILVEIRA, duly seconded by RICCHIUTI and carried THAT the Research Subcommittee fund Dr. Adaskaveg's two projects, one for $9,000 and $21,250 for a total of $30,250 for Fiscal Year 2022.

<u>Motion 11-10-2021 #3</u> **APPROVED**

MOVED by RICCHIUTI, duly seconded by HEUER and carried THAT the Research Subcommittee fund Dr. Carol Lovatt project for $29,217 for Fiscal Year 2022.

<u>Motion 11-10-2021 #4</u> **APPROVED**

MOVED by HEUER, duly seconded by C. BURRESON and carried THAT the Research Subcommittee fund Dr. Drakakaki project of $115,151 for Fiscal Year 2022.

<u>Motion 11-10-2021 #5</u> **APPROVED**

MOVED by RICCHIUTI, duly seconded by ZAVOLTA and carried THAT the Research Subcommittee fund Dr. Giulia Marino's project of $46,610.10 for Fiscal Year 2022.

<u>Motion 11-10-2021 #6</u> **APPROVED**

MOVED by DELEONARDIS, duly seconded by ZAVOLTA and carried THAT the Research Subcommittee fund Dr. Ehsani's project of $34,902 for Fiscal Year 2022. Only two (2) board members voted nay on the project, Mark Heuer and Pat Ricchiuti.

<u>Motion 11-10-2021 #7</u> **APPROVED**

MOVED by SILVEIRA, duly seconded by RICCHIUTI and carried THAT the Research Subcommittee fund Jim Stewart's project of $11,000 and Ernie Simpson's project of $9,250 for Fiscal Year 2022.

Motion 11-10-2021 #8 **APPROVED**

MOVED by SILVEIRA, duly seconded by C. BURRESON and carried THAT the Research Subcommittee approve the contingency Fund of $35,000 for Fiscal Year 2022. (MOTION 11-10-21 #8)

Motion 11-10-2021 #9 **APPROVED**

MOVED by HEUER, duly seconded by DELEONARDIS and carried THAT the Research Subcommittee grant authority to the Executive Director in conjunction with the Chairman to approve requests for no-cost extensions

Motion 11-10-2021 #10 **APPROVED**

MOVED by HEUER, duly seconded by D. BURRESON and carried THAT the Research Subcommittee grant authority to the Executive Director and Chairman for inter-item transfers of the Research Budget.

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

FROM: RESEARCH SUBCOMMITTEE

SUBJECT: REVIEW OF 2021 RESEARCH FINAL REPORTS

BACKGROUND:

2021 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
Giulia Marino Louise Ferguson	Timing Ethylene Applications as a Function of Heat Unit Accumulation	$24,470
Carol Lovatt Elizabeth Fitchtner	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 Pseudomonas savastanoi pv.savastanoi	$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
	Total	**$303,360**

CALIFORNIA OLIVE COMMITTEE

2021-2022 CROP YEAR FINAL REPORT

Workgroup/Department: Olive / Plant Sciences, UC Davis

Project Year : April 1, 2021 – June 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:
Ms. Emily Santos MS: Asst. Specialist, UC Davis
Dr. MinMin Wang: Postdoctoral Scholar, UC Davis
Dr. Georgia Drakakaki: Professor, UCDavis
Dr. Reza Ehsani: Professor, UC Merced
Dr. Richard Rosecrance: Professor, Chico State University
Mr. William H. Krueger MS: Farm Advisor Emeritus
Mr. Erick Nielsen: ENE Inc., pruning and harvesting designer, fabricator and contractor.

Research Summary:
Our 2021 results demonstrate 'Manzanillo' table olives require 1400 to 2000 Growing Degree Days, GDD, above 15*C or 59*F past full bloom to achieve full size. Also, at 2000 GDD the Fruit Detachment Force begins to decline to 0.2 kg or 0.5 lb, the point at which mechanical harvesting becomes more efficient. While our results in 2021 did not result in a significantly higher harvester efficiency with Ethephon® they did demonstrate there is the potential to predict when to best apply Ethephon® by correlating declining FDF with GDD.

Secondary useful results demonstrated the trunk shaking harvester consistently ranged from 50-80%, and when combined with Ethephon® treatments, did not decrease fruit value per ton or increase postharvest leaf drop unless shaking was excessively long, above 15 seconds.

Introduction:
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 on fruit removal force were erratic. As our years of spray trials have not yielded reliable results in this trial we proposed a different approach.

All fruit growth is a function of heat. All fruits have a specific "accumulated heat unit requirement to mature; **G**rowing **D**egree **D**ays; **GDD**. We proposed characterizing 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 stages can be predicted as a function of accumulated GDD. Hopefully, by using accumulated heat units past bloom to determine when an olive fruit is mature, and receptive to ethylene, we can better target when to apply Ethephon®. We have developed a model like this for pistachios that predicts kernel growth and hull split in six different cultivars.; https://ucanr-igis.shinyapps.io/pist_gdd/. This model is now used to determine pest management, deficit irrigation and harvest timing.

We proposed to do this by monitoring temperature accumulation, GDD, and olive fruit growth in two locations, and as maturity approached, started testing fruit removal force. When the fruit removal force began to decline we did whole tree Ethephon® applications, and continued testing fruit removal force until fruit the fruit was ready for harvest. At that time the treated and control trees were 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.

Materials and Methods:

Experimental Sites:
Two orchards pruned for trunk shaker harvesting used secured:

1. Nickels Soils Laboratory moderate density (202 tree/acre) orchard in Colusa County
2. Glenn County Orchard, 180 trees per acre (Cooperator: Burreson Orchards)
    - In each orchard 3 sets of 2 rows each were selected in March 2021

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

Data loggers that measured temperature accumulation were installed in March 2021 before bloom.

At 50% full bloom, ~ May 1st 2021 the loggers started logging daily temperatures and **G**rowing **D**egree **D**ay (GDD) accumulation was calculated as follows using a Tbase = 15*C or 59*F (Pérez López et al. 2008)

$$GDD = [(Tmax + Tmin)/2] - Tbase$$

Fruit Growth Measurements:
When olives were ~ 1cm in length, 3 sets of 40 (Orland) or 60 (Arbuckle) olives/treatment were collected weekly:

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

Fruit Removal Force (FRF) Measurements:
When olive volume growth started to slow, and the fruit began to develop the yellow green straw color or purple blush of maturity, the **F**ruit **D**etachment **F**orce (**FDF**), or pull force, measurements were begun with an Imada pull force gauge on 40 (Orland) or 60 (Arbuckle) olives per treatment replication.

Ethephon Treatments:
When fruit removal force began declining, and/or the fruit showed color, ethylene treatments were started:
3 rows x 3 trees = 9 trees per treatment and a control each, were sprayed to drip @ 100 GPA rate with:

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

The spray treatments were done on:
Arbuckle:
September 10th @ ~ 2000 GDD
September 13th @ ~ 2050 GDD
September 16th @ ~ 2100 GDD

Orland:
September 9th @ ~ 2000 GDD
September 13th @ ~ 2050 GDD
September 16th @ ~ 2100 GDD

When the FRF began to drop for 3 sequential samplings (over 6 days), or by 50% in any one of the spray timings treatments, the trees were harvested

Harvesting
In both orchards we used trunk shaking harvesters @ ~ 6-10 seconds per tree.

Arbuckle:
Mechanical harvest: September 22nd
Hand harvest: October 2nd

Orland:
Mechanical harvest: September 28th
Hand harvest: October 5th

Harvested weight of 3, 3 tree sets were combined, weighed and one 20 Lb. sample collected and submitted for grading value at the Musco Orland Receiving Station.

Trees were hand gleaned; this fruit was weighed but not graded

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

$$\frac{\textit{weight (lbs.) of mechanically harvested olives}}{\textit{weight (lbs.) of mechanically+ hand harvested olives}}$$

Statistical Analysis:
An Analysis of Variance, ANOVA, with and LSD means separation test compared harvester efficiency of Ethephon® 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 were evaluated for leaf drop on April 25th 2022. The trees were rated visually for leaf drop on a 1-3 scale: 1= none, 2 = visible, 3 = severe.

Data were analyzed using ANOVA with an LSD means separation.

Results and Discussion:

I. Measuring Fruit Growth and Maturity as a Function of Temperature:

The objective of the experiment was to determine if we could better determine when to apply Ethephon® by measuring olive fruit growth and the decline in pull force as a function of accumulated heat units. To do this we began measuring growth as a function of heat accumulation starting with full bloom. This data is shown in Figures. 1 and 2, fruit growth as a function of heat, in both experimental orchards. As can be seen both sets of figures, in the length or longitudinal axis, width or transverse axis, and volume, collectively the size of the olives, there was a slight difference in the maximum size of the olives, and how many GDD days it took to achieve the maximum size, between the two locations. Olives in the Arbuckle orchard achieved a maximum volume of 3 cc^3at 1400 GDD by August 1st. Olives from Orland achieved a maximum volume of 3.7 cc^3 at 1600 GDD by August 15th. This demonstrates olives can continue to achieve size through at least 1600 GDD from bloom if their irrigation and nutritional needs are met.

We have no explanation for the 20% larger size olives produced in Orland versus Arbuckle; p[possibly crop load. The smaller Arbuckle trees @ 202 trees to the acre produced an average of ~60 pounds per tree, ~ 6.1 tons per acre valued at an average of $1325 per ton; see Fig. 5. A. The larger Orland trees at 180 trees per acre produced an average of ~66 pounds per tree and ~ 6.0 tons per acre valued at $1225 per ton; see Fig. 5. B. The difference in final production between the two orchards was < 2 %. Also, this size difference did not increase the value per ton as the olives from Orland received ~ $100 less per ton than the olives from Arbuckle. However, the data does demonstrate using 80% of the orchard area for producing canopies, either with smaller trees more closely spaced or larger trees spaced further apart, the net production will be approximately equal. The determination to then be made is which canopy harvests mechanically with greater efficiency. This determination must also incorporate what kind of harvester, trunk shaking or canopy contact, is to be used.

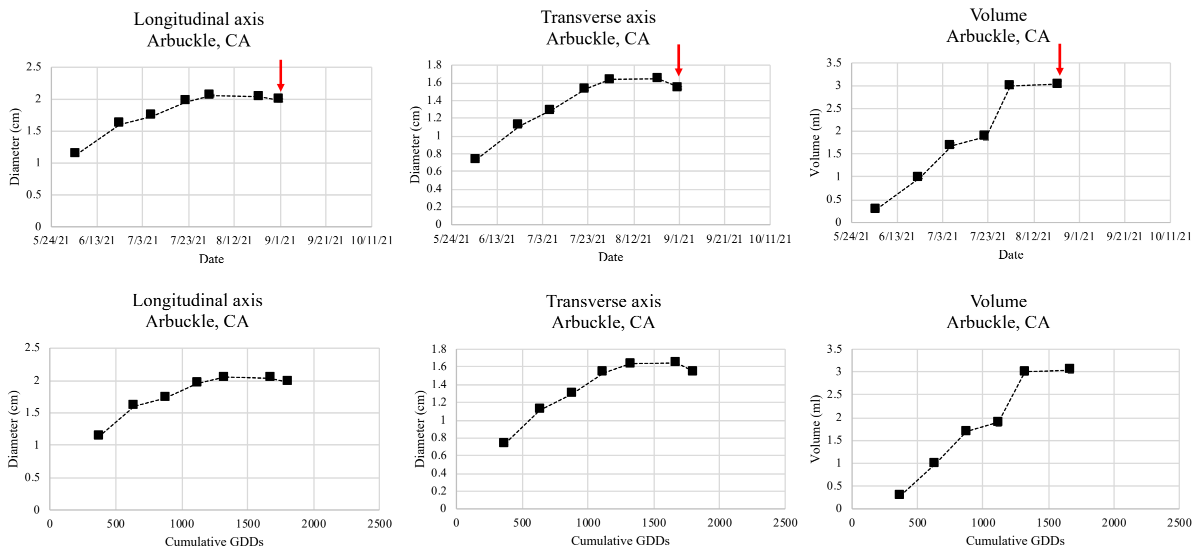


Fig. 1

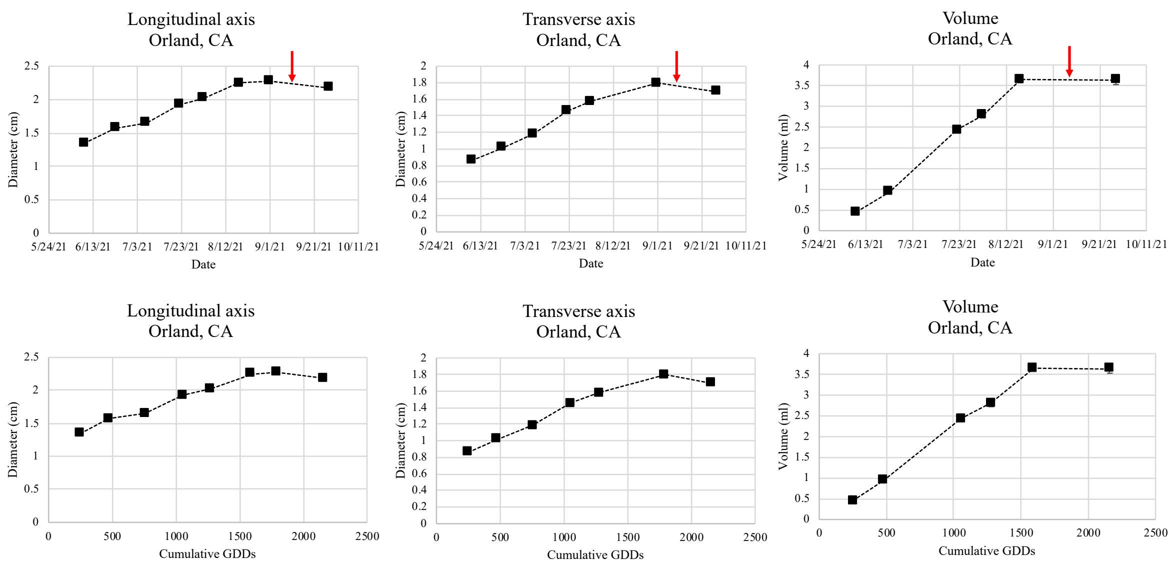
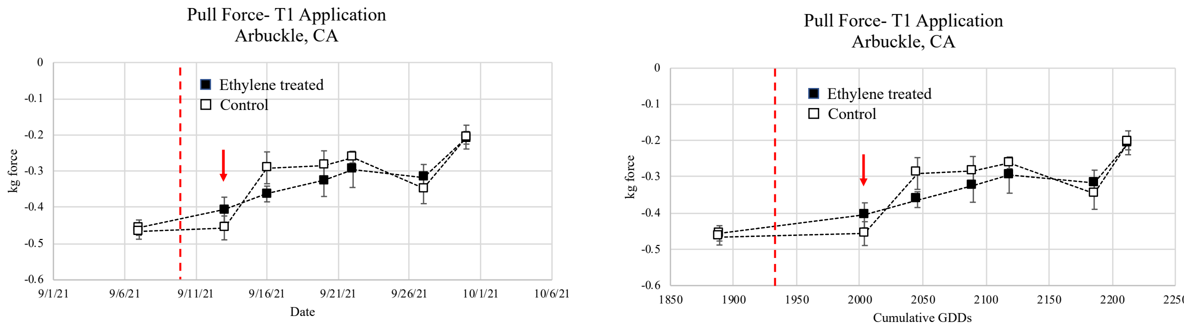


Fig. 2

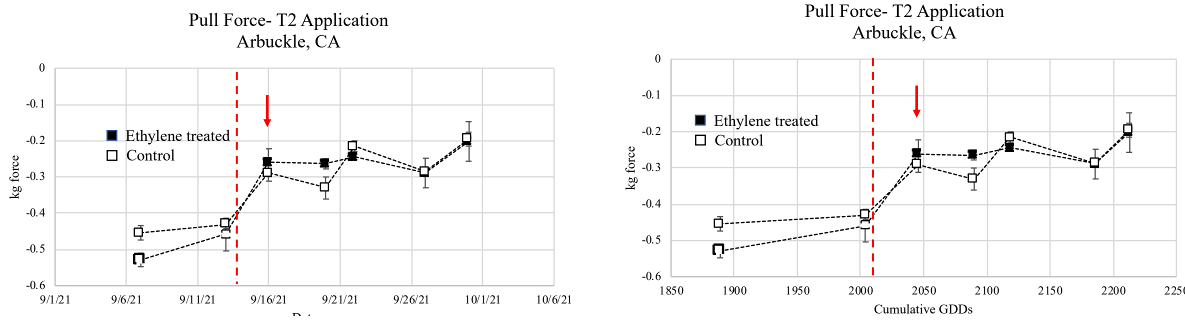
Fig.1 (top) and Fig. 2 (bottom) demonstrates the growth curve for olives from bloom through full size; the olives in Arbuckle required 1400-1600 to achieve full size by early August versus mid-August for the olives in Orland. The error bars are too small to see indicating the data is very consistent. The error bars represent +/- standard deviation error across four replicated plots of control using a total of (n=40 or 60) number of olives. The red arrow indicates when ethylene treatments began.

II. Effect of Ethephon® on Fruit Detachment Force (FDF)

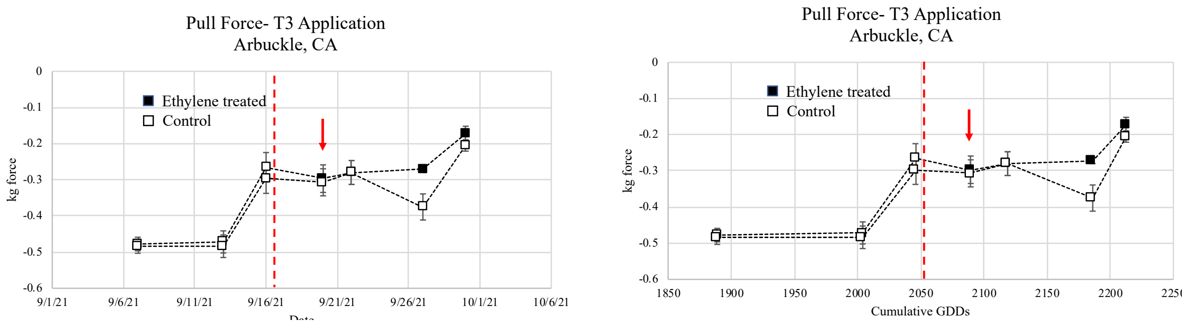
As can be seen in Figures 3. A, B, C and 4. A, B, C below Ethephon® applied on three sequential GDD accumulations between 1980 – 2050 GDD failed to produce a consistent significant decrease in FDF between the control and sprayed trees in either location. However, what this data does show is that FDF decreases above 2000 GDD and in future trials we should focus on applying Ethephon® after 2000 GDD and when FDF has decreased to – 0.25 kg, about 0.5 lbs. Then, what we will need to determine is how quickly to harvest after Ethephon® application to avoid the over ripeness that increases color and harvester damage, both lower fruit value.



A.

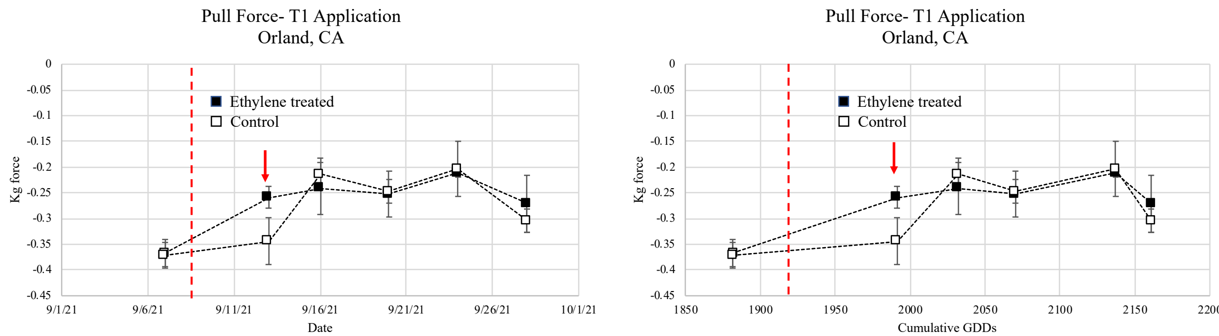


B.

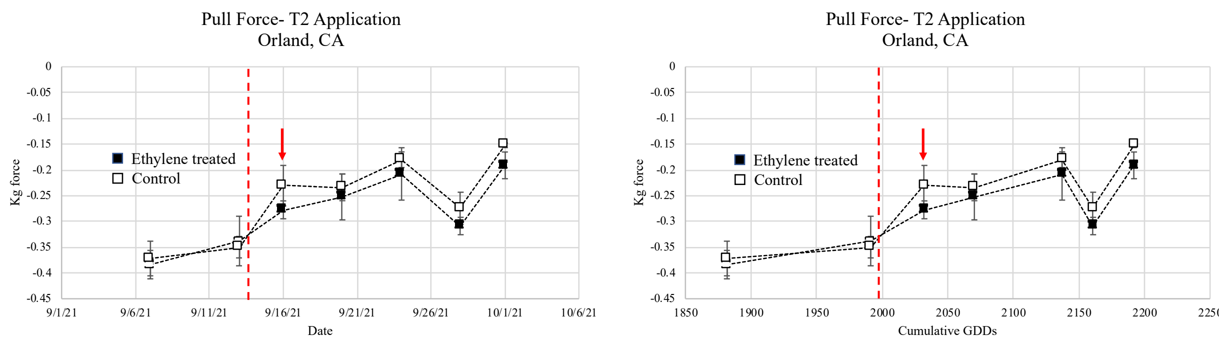


C.

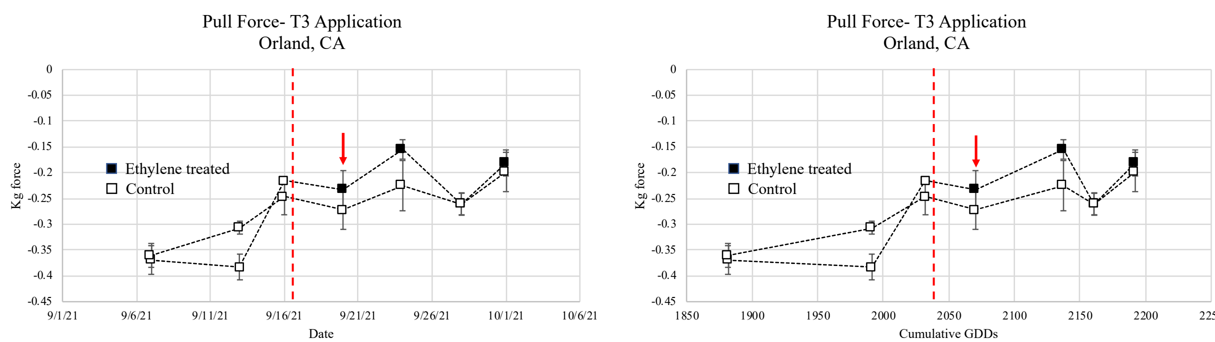
Fig. 3: A, B , C. The three graphs above demonstrate the decrease in **F**ruit **D**etachment **F**orce, **FDF** in kilos (1 kg = 2.21 Lb.) before and after the three sequential spray treatments. The red dotted vertical line indicates the first, A, second, B, and third, C, ethylene applications. The red arrow indicted the first pull test after ethylene application. Error bars represent +/- standard deviation error across four replicated plots per treatment using a total of (n=60 or 40) olives. As can be seen above there were few consistent significant differences in pull force between the controls and Ethephon® treated trees. The few significant differences in FDF between the controls and treated olives dissipated within three days or 30 GDD.



A.



B.

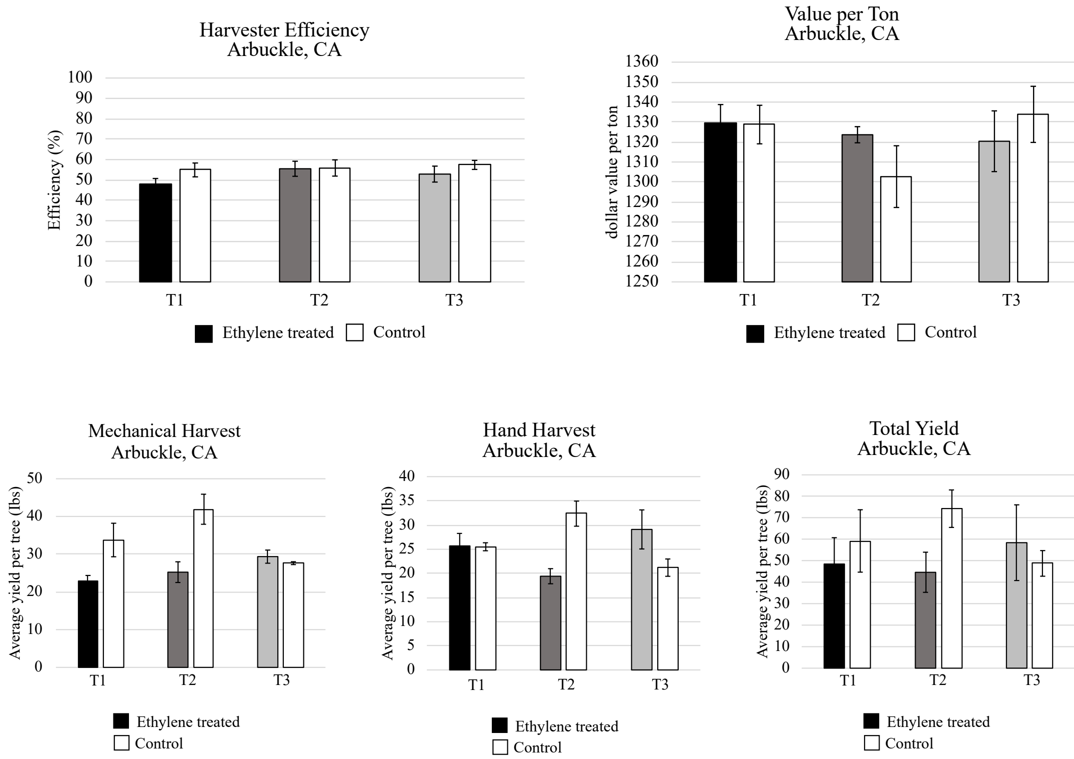


C.

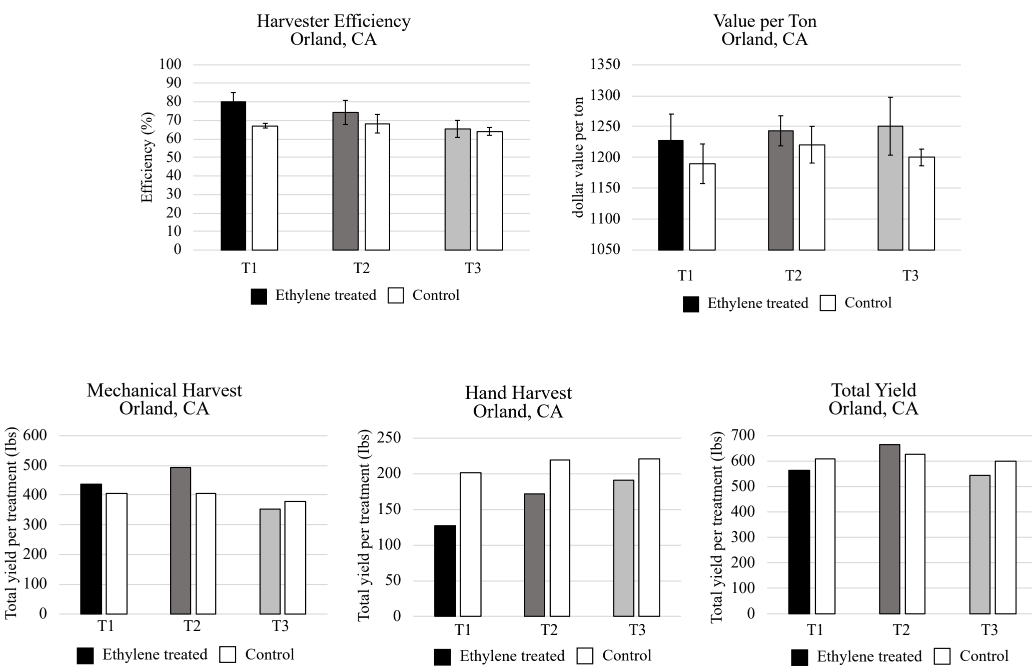
Fig. 4: A, B , C. The three graphs above demonstrate the decrease in **F**ruit **D**etachment **F**orce, **FDF** in kilos (1 kg = 2.21 Lb.) before and after the three sequential spray treatments. The red dotted vertical line indicates the first, A, second, B, and third, C, ethylene applications. The red arrow indicted the first pull test after ethylene application. Error bars represent +/- standard deviation error across four replicated plots per treatment using a total of (n=40) number of olives. As can be seen above there was only a single significant difference in pull force between the controls and Ethephon® treated trees; this with the first treatment, A, September 9th at 2100 GDD, and this difference dissipated within three days or 30 GDD.

III. Effect of Ethephon® on Harvester Efficiency and Olive Value per Ton

Figures 5. A and B below demonstrate, as would be expected if pull force was not significantly decreased, the harvester efficiency was not significantly increased. In the Arbuckle location Ethephon® did not produce significant differences in harvester efficiency or value per ton versus the control. However, in the Orland orchard the harvester efficiency was significantly increased by the Ethephon® treatment; 80% of the trees' olives, versus 65% for the control treatment, were harvested mechanically. What is important to note in this collective data is that harvester efficiency ranged from 50 to 80% and did not significantly decrease the value of the olives at the grading station.



A.

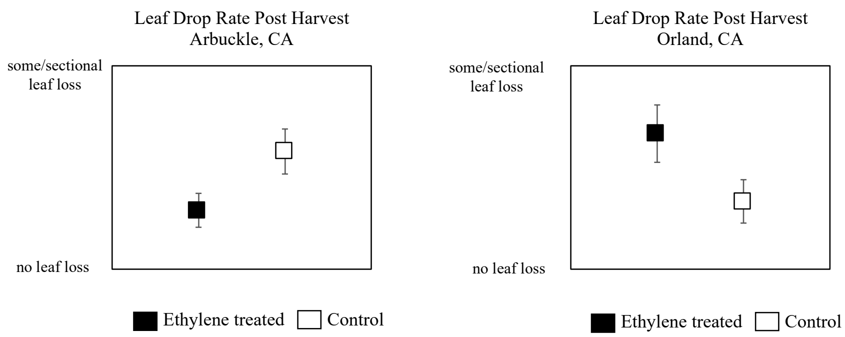


B.

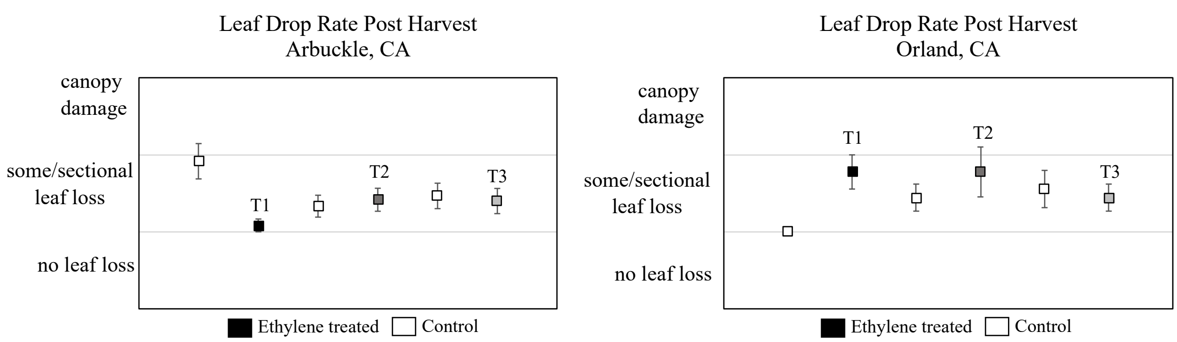
Fig. 5. A, B. The graphs above demonstrate Ethephon® had no consistently significant effect on harvester efficiency, value per ton, or the percentage of fruit harvested by machine except in Orland; there the mechanical harvester removed 80% of the olives with the earliest Ethephon® spray. Of particular note is that the Ethephon® spray and mechanical harvesting did not significantly decrease the olive value at the receiving station.

IV. Effect of Ethephon® on Postharvest Leaf Drop

The Ethephon(R) treatments gave conflicting results at the two orchard locations. As can be seen in Figures 6. A and B below the average, A, and by treatment, B, postharvest leaf drop was significantly lower with Ethephon(R) in the Arbuckle orchard and significantly higher in the Orland orchard. Having observed the harvesting in process, we believe this to be a function of the harvester operator using excessive force and extended shaking the trees. This may also be the reason this orchard returned a lower value per ton; there may have been more fruit damage.



A.



B.

Fig. 6. A, B. The two sets of graphs above demonstrate the Ethephon® treatments had significantly different and conflicting effects on postharvest leaf loss. We attribute the significantly higher leaf loss in the Orland orchard to the observation that the shaker operator was shaking the trees excessively; this combined with the Ethephon® resulted in significantly higher leaf loss. However, in both orchards postharvest leaf loss was minimal.

V. Discussion and Conclusions

Our results strongly confirm the reports in the literature; harvester efficiency is strongly correlated with FDF (Zipori et al., 2014). Our 2021 data confirms this, see Fig. 7 below. Lowering FDF is key to increasing mechanical harvesting efficiency. .

This decrease in fruit removal force during the harvest season has been consistently observed in both table olives and oil olives; immature olives have FDF 0.5 kg (~ 1.1 lb.) versus mature olives with FDFs of 0.2 kg (~ 0.5 lb.) (Blanco-Roldan et al., 2009; Zipori et al., 2014; Alowaiesh et al., 2016). This is consistent with our results suggesting FDF is a reliable indicator of olive fruit maturity.

GDD has now been demonstrated to predict growth and harvest timing for other tree crops, for example, pistachio (https://ucanr-igis.shinyapps.io/pist_gdd/, Zhang et al., 2021). If FDF decline could be reliably predicted by GDD accumulation, this GDD accumulation could theoretically be used to schedule Ethephon® applications to increase harvester efficiency.

This is the approach we will be collectively pursuing with Dr. Georgia Drakakaki in our 2022 trial. We will investigate how to better predict using GDD to predict the drop in FDF to better time Ethephon® applications to accelerate the decrease in FDF and increase harvester efficiency.

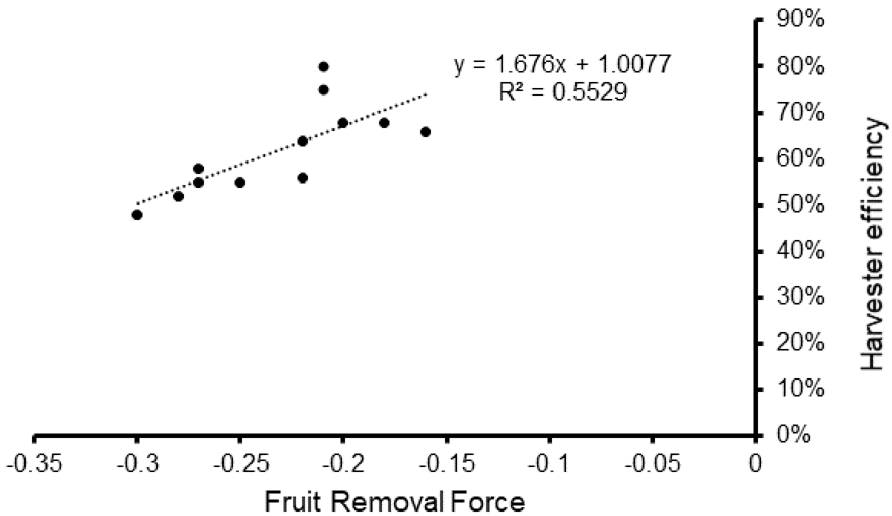


Fig. 7. Relationship between FDF and harvest efficiency in 2021 harvesting trials.
(Figure courtesy of MinMin Wang)

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Department of Botany and Plant Sciences
Relevant AES/CE Project No.: 4556

University of California
Division of Agricultural Sciences

FINAL REPORT
(Year 2 Final Report January 1, 2021, with a NCE through June 30, 2022)

Project Year: 2020 (Year 1) **Anticipated Duration of Project:** This was year 2 of a 3-year project. Due to back-to-back

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

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

Objectives for 2021 (Year 2). ***Background.*** Alternate bearing (AB) is the production of a heavy, high-yield "on-crop" followed by a light, low-yield "off-crop". The alternating high and low yields result in significant economic problems. In ON-crop years, trees produce an unacceptable quantity of small fruit with reduced commercial value. In OFF-years, trees produce large fruit, in some cases too large, and too few fruit to provide growers with a good income. It is important to note that the lack of fruit in the OFF-crop year, if more or less industry-wide, has a negative economic impact on every step in the production chain from farm to consumer, including orchard management, harvesting, processor operation, manufacture of value-added products, marketing, and consumer prices, which jeopardizes the stability and sustainability of the olive industry. Climate is the major factor initiating AB. Abnormally high or low temperatures, water-deficit stress or excessive winter rain causing soil hypoxia etc., which 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 when it occurs.

The current research project is based on our discovery of the four mechanisms by which the ON-crop of olive fruit reduces return bloom the following year and perpetuates alternate bearing (AB) in 'Manzanillo' olive trees:

(1) inhibition of summer vegetative shoot growth (Sibbett, 2000);
(2) abscission of floral buds during the summer after pit hardening;
(3) inhibition of floral development at the level of gene transcription; and
(4) inhibition of spring bud break.

Keep in mind that all four effects are more severe on bearing shoots of ON-crop trees, the majority of shoots, than they are on non-bearing shoots of ON-crop trees due to the combined effects of the fruit set on the shoot and crop load (the total number of fruit per tree). Also note that the OFF crop has the opposite effect for each mechanism. Taken together, the four negative effects of the ON-crop on return bloom, especially the abscission of more than 70% of the floral buds for next year's bloom and the inhibition of floral gene transcription caused by the ON crop of fruit, make it abundantly clear that early fruit thinning (before pit hardening) with the goal of increasing the number of nonbearing shoots is necessary to mitigate alternate bearing in 'Manzanillo' olive. Moreover, fruit thinning, which increases the number of non-bearing shoots, will improve the efficacy of PGR treatments that increase summer vegetative shoot growth, improve retention of floral buds, and stimulate spring bud break to increase floral intensity following the production of the ON crop (Fichtner and Lovatt, 2016; Fichtner et al., 2017).

The overall goal of our research is to develop a management strategy that maximizes total yield and yield of commercially valuable size fruit annually such that the sum of two annual yields is greater than the sum of the ON/OFF yields of an alternate bearing cycle.

Objectives for 2021:

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 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 also increases fruit size, which is needed in the ON-crop year (Fichtner and Lovatt, 2018; Fichtner et al., 2017). This treatment was applied to trees in the NAA and pruning treatments. Applications were made in February just prior to spring bud break (this was proven in earlier research to be the best application time for increasing 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. In addition, trees treated with NAA or pruned and not treated with the proprietary PGR were compared with trees that were treated with it. The experiment utilizes a randomized complete block design with 16 individual tree replications per treatment using 'Manzanillo' olive trees in a block, which includes 'Sevillano' olive trees as the pollenizer planted at a ratio of one to ten, at the Lindcove REC in Exeter, CA. The plan was to modify the treatment schedule as needed to best manage light or heavy blooms when AB reoccurs. Total yield and fruit size distribution as kg/tree was determined at harvest and used to calculate total yield and fruit size distribution as fruit number per tree. Fruit quality was evaluated for the proportion of green, partially green, partially black, and black fruit. Alternate bearing index was calculated.

The final strategy will be one that succeeds in achieving annual yields that are significantly greater than OFF-crop yields and equal to 60% to 70% of the average ON-crop yield for an orchard with the 2-year cumulative yield distributed equally in each year of a 2-year cycle and with total yield and yield of commercially valuable size fruit greater than sum of the 2-year ON-/OFF-crop cycle in the alternate bearing orchard.

Research Accomplishments for 2021.

1) **Treatment effects on return bloom in 2021.**

A visual in-field 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 valuable information on the effects of treatments applied the previous year (2020) on return bloom in 2021 and provide evidence of the benefit of the spring cytokinin treatment to enhance bloom (Table 1; compare treatment 2 with treatment 5 and treatment 3 with treatment 6). Trees receiving the cytokinin-PGR treatment also had significantly greater total yields compared to their counterparts in NAA and 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 several consecutive years to ascertain whether treated trees 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 in-field 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 ($r = 68$, $P < 0.0001$). This relationship has proven strong over 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 (Fig. 1). 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., a 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, with the yield of fruit in these two size categories now approximately 50% of 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, yields > 120 kg per 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 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 define an upper threshold value for the bloom estimate that indicates that crop removal treatments need to be utilized.

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 ON-crop control trees selected in 2017 (treatment 4) have continued to produce alternating ON and OFF crops (Table 2). These trees were ON-crop trees in 2021. The trees 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.

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, and after harvest for average total yield, and average yield of medium+large size fruit for each 2-year ON/OFF cycle (Table 3). ABI = (year 1 bloom or yield – year 2 bloom or yield)/ (year 1 bloom or yield + 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 3). 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 3). 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 3). 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.

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 (based on bloom estimates), significantly increased total yield and tended to increase yield of medium+large size fruit (not statistically 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 evaluate the efficacy of 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 stopped 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] Treatments Completed	2021 Treatments To be done	2021 Bloom estimates (Before 2021 treatment) West side of tree	East side of tree	Average per tree	Sum per tree	2021 yield kg/tree	2021 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
P-value		0.0018	< 0.0001	< 0.0001	< 0.0001	0.0004	0.3238

[z] Bloom was evaluated on the following scale: 0, no inflorescence; 1, low floral intensity; 2, medium floral intensity; and 3, high floral intensity.
[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.
[x] Mean values within a vertical column followed by different letter s are significantly different at the specified *P* level by Fisher's Protected LSD test.

Table 2. Effects of crop load and two fruit thinning treatments, foliar application of the PGR NAA at full bloom and pruning after full bloom (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
P-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.

Table 3. 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.

2019	2020	2021	2019			2020			2021			2019+2020 ABI			2020+2021 ABI		
	Treatment[y]		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)	M+L (kg/tree)	Bloom sum (east+ west)	Total yield	M+L	Bloom sum (east+ west)	Total yield	M+L
1 OFF-crop control	ON-crop control	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 treat-ment	NAA-West side of tree	NAA – 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 treat-ment	Pruned-West side of tree	Pruned – 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	OFF-crop control	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	NAA-East side of tree	NAA – No treatment, Cytokinin PGR applied Feb+July to full canopy	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	Pruned-East side of tree	Pruned – No treatment Cytokinin PGR applied Feb+July to full canopy	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
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.

[x] 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.

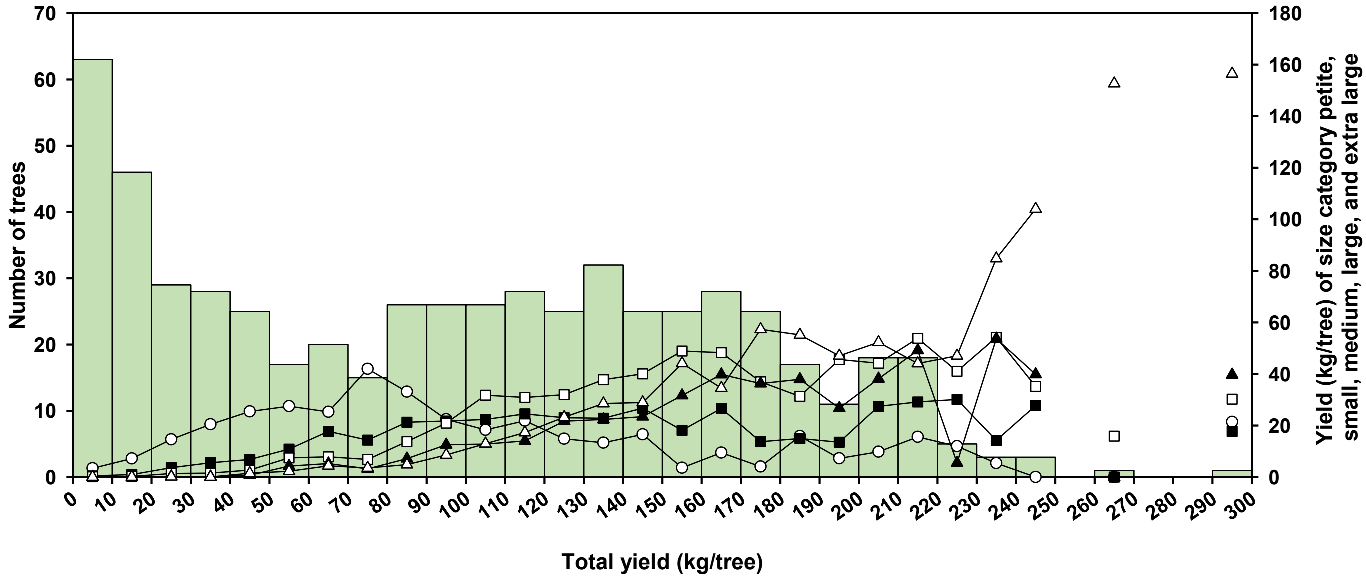

Figure 1. The green bars are the number of trees in the data set having total yields of 0-10 kg/tree, > 10-20 kg/tree, > 20-40 kg/tree, etc. The lines indicate the change in yield (kg/tree) for fruit of packing carton sizes Petite (2.52-3.23 g) (-Δ-), Small (3.24-3.55 g) (-▲-), Medium (3.56-4.30 g) (-□-), Large (4.31-5.00 g) (-■-) and X-Large (5.01- 6.98 g) (-○-) as total yield increases.

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%.

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.

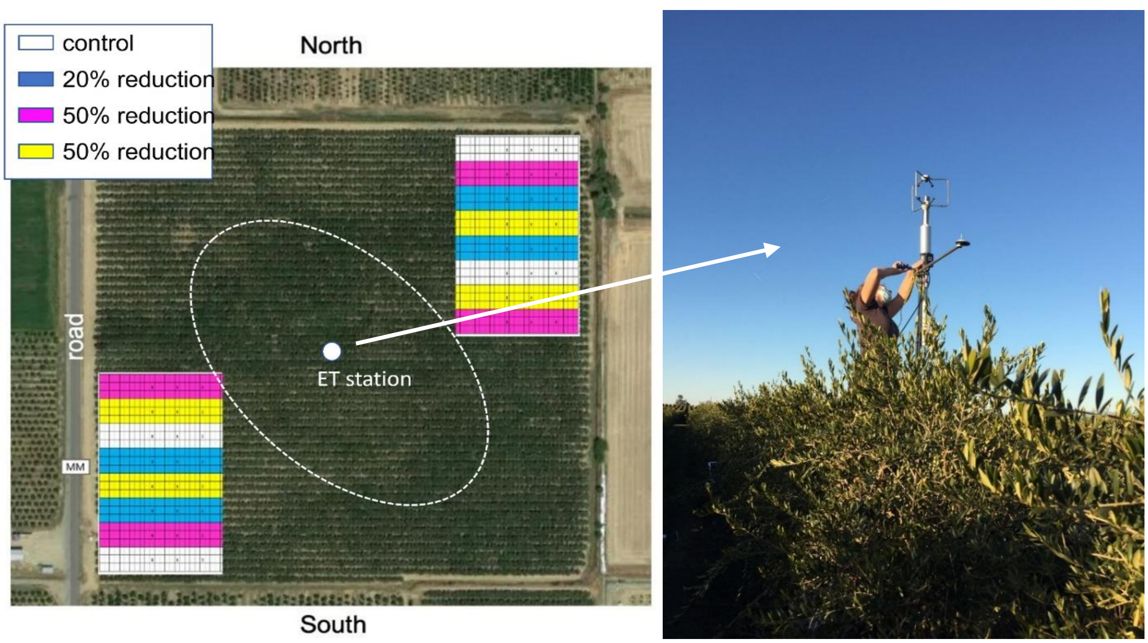

Figure 1. *Map of the experimental design with the replication of the different blocks, the location of the ET station, and an example of the measurement area of the station (dashed circle); the legend indicates the correspondence between the map blocks/colors and deficit irrigation treatments. On the left: sensors' setup installed above canopy to measure ET.*

Soil moisture sensors (Watermark Irrometers) were installed at 18, 36 and 48 in depths in one location per each treatment, in early May 2021. 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 reinstalled them in 2022.

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%. Two blocks were assigned to the 50% water application treatment since we planned to manage them differently during the second year of the project. This option was later discarded since full irrigation, which was the basis for such differentiation, cannot be achieved. Thus, we kept 3 treatments in 2022.

On March 31st, 2021 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).

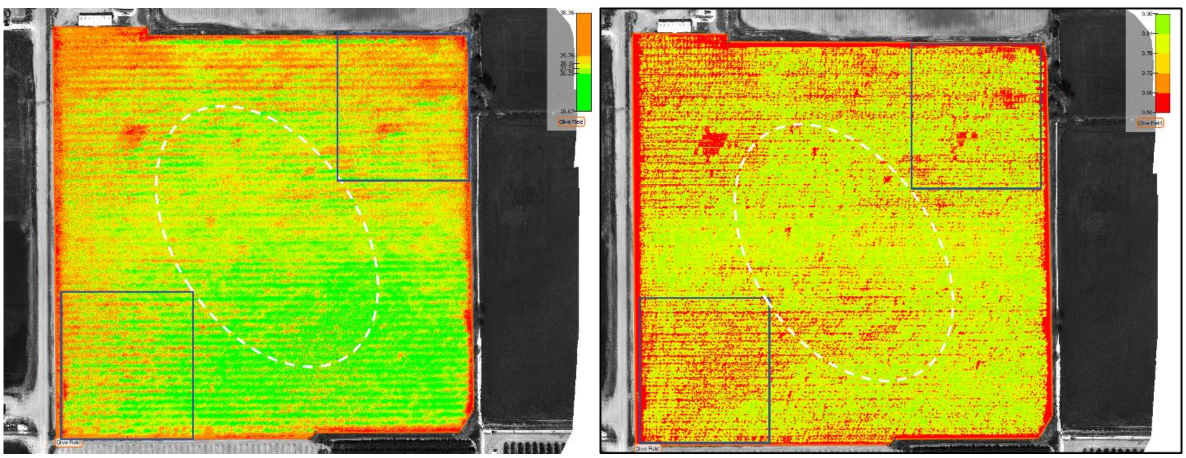

Figure 2. *Thermal and multispectral images of the olive orchard showing difference in canopy cover and temperature within the whole orchard and experimental blocks. The blue squares roughly represent the location of the deficit irrigation treatments areas and the dashed circle is a rough estimate of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

On the three selected trees per block (12 trees per treatment), starting in March, we measured weekly midday stem water potential (SWP), and biweekly vegetative growth on one selected branch per tree. Only in the control treatment we also characterized biweekly flower phenology 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 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, 2021. 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.

Results

The olive actual evapotranspiration (ETa, Fig. 3a), that is the evapotranspiration values measured at the experimental site with the ET station, increased from 0.15 in/day at the end of May to 0.20 in/day at the beginning of July. From mid-July ETa decreased constantly to values of 0.1/0.15 in/day observed until the first half of August and to values of 0.1 in/day observed in late August and September. This decrease was also observed in the reference ET from the closest CIMIS station. The crop ET (ETc), the daily ET calculated as the factor of ETo from the closest CIMIS station and the suggested Kc of 0.75, was 0.03 inches higher than the ETa.

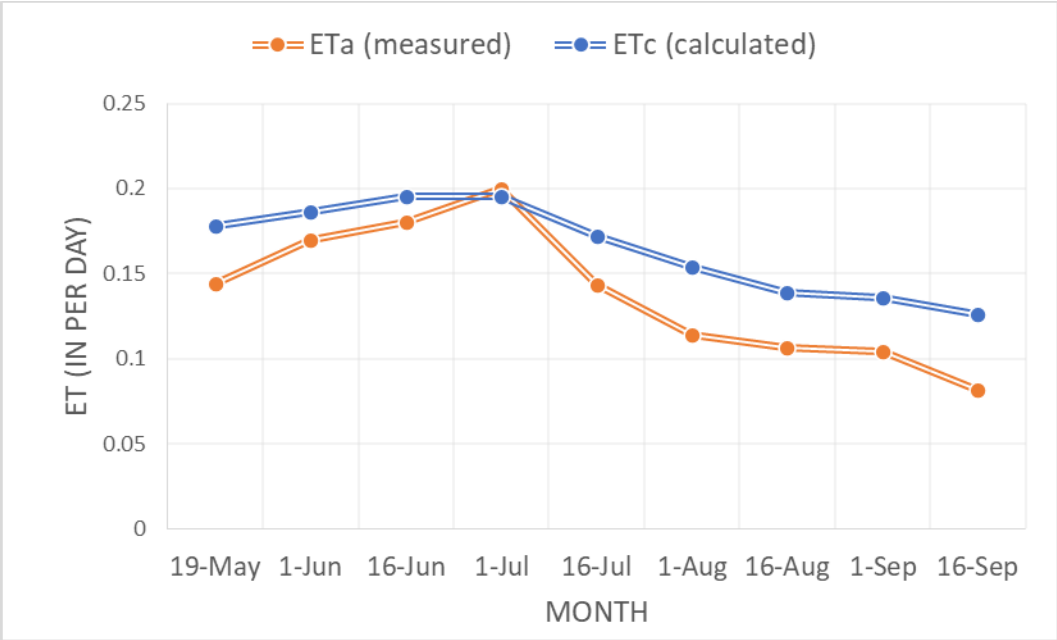

Figure 3a. *Olive actual evapotranspiration (ETa, inches per day), measured at the experimental site with an ET station (orange line) in comparison to the ETc or crop evapotranspiration calculated using the reference ETo from the close CIMIS station and the suggested crop coefficient of 0.75 (blue line)*

Monthly cumulative values of ETa were 5.5 inches in June and July and decreased to 3.5 and 2.5 inches in August and September (Fig 3b). The ETa values in June and July were similar to the ETc calculated using the Kc of 0.75, while in August and September measured values were 1 inch lower than the calculated ones.

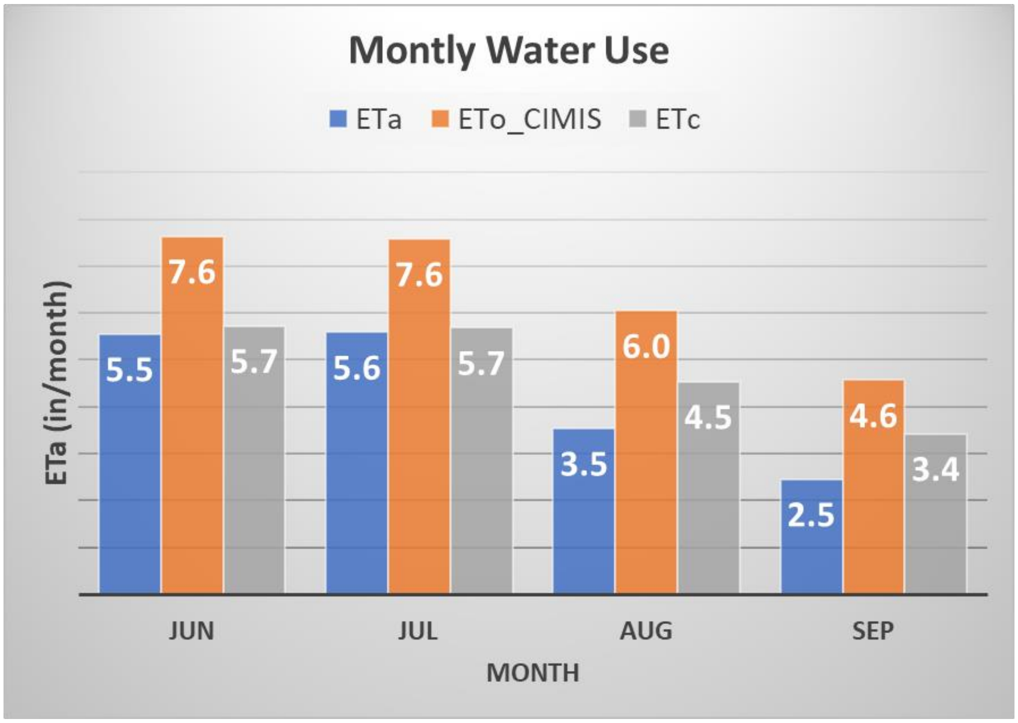

Figure 3b. *Monthly values of olive actual evapotranspiration, ETa, (inches per month) measured at the experimental site with an ET station in comparison to the reference ETo from the closest CIMIS station and the ETc or crop evapotranspiration calculated using the suggested crop coefficient of 0.75*

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.

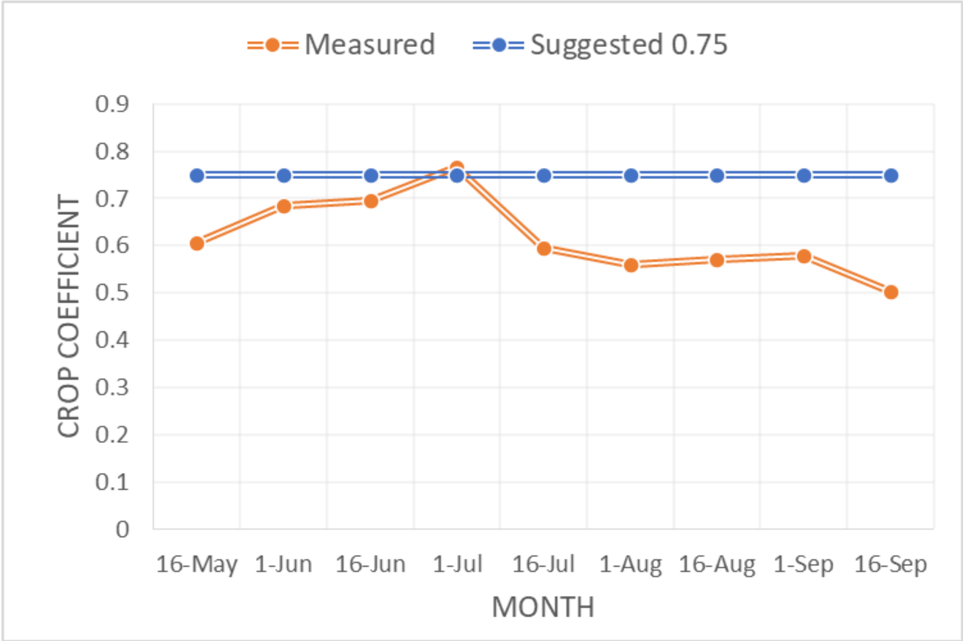

Figure 4. *Olive crop coefficient measured at the experimental site (orange line) in comparison to the suggested Kc value of 0.75 (blue line)*

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 also associated with an overall increase in vapor pressure deficit (hottest/driest air). Because vapor pressure deficit is important driver for evapotranspiration, increase in ETa and Kc values were 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 blocks is likely to be associated with the heterogeneity of the orchard, despite the randomization of the blocks should have smoothed this difference out.

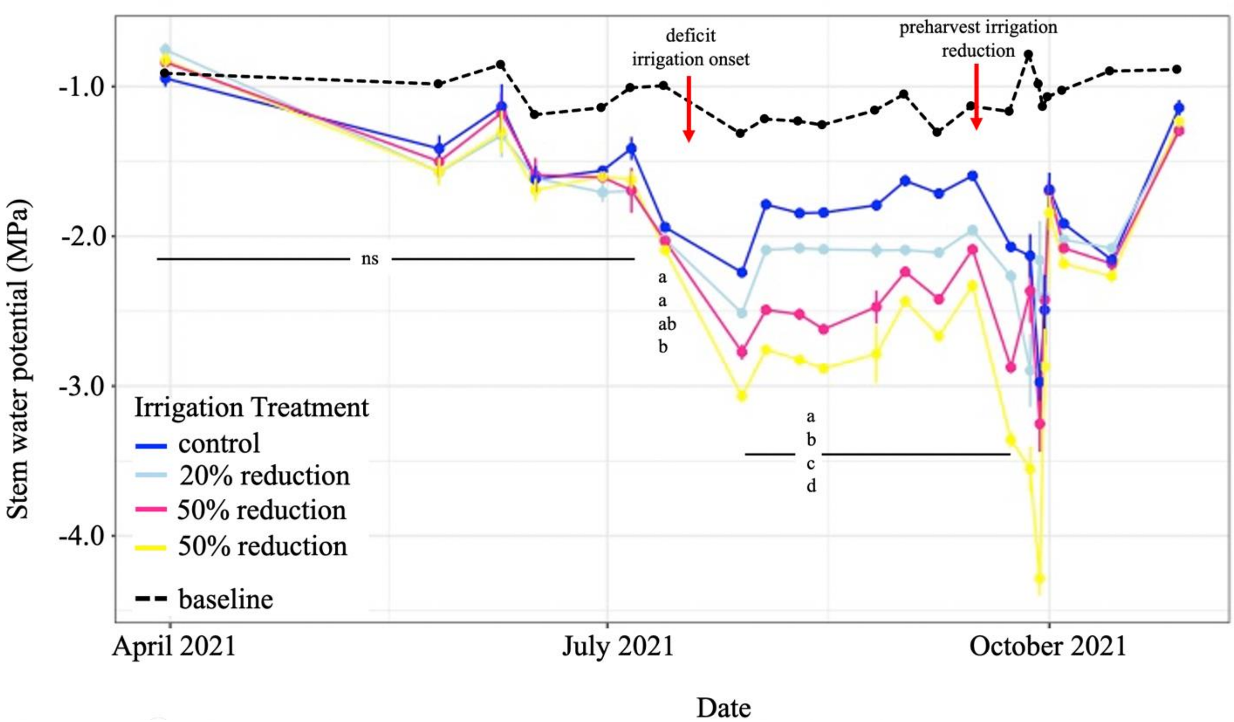

Figure 5. *Seasonal variation of the stem water potential (MPa) of the control treatment in comparison to the baseline (Shackel et al., 2021), and the three deficit irrigation treatments. The baseline represents the potential SWP values of fully hydrated olive trees from data on literature. Different letters indicate significant differences among treatments. ns = non significant*

Details of tree water status represented as SWP in the week before harvest, when irrigation was withheld, and later, when trees were rewatered, 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 restoring irrigation. No differences were observed among treatments from the 1st of October.

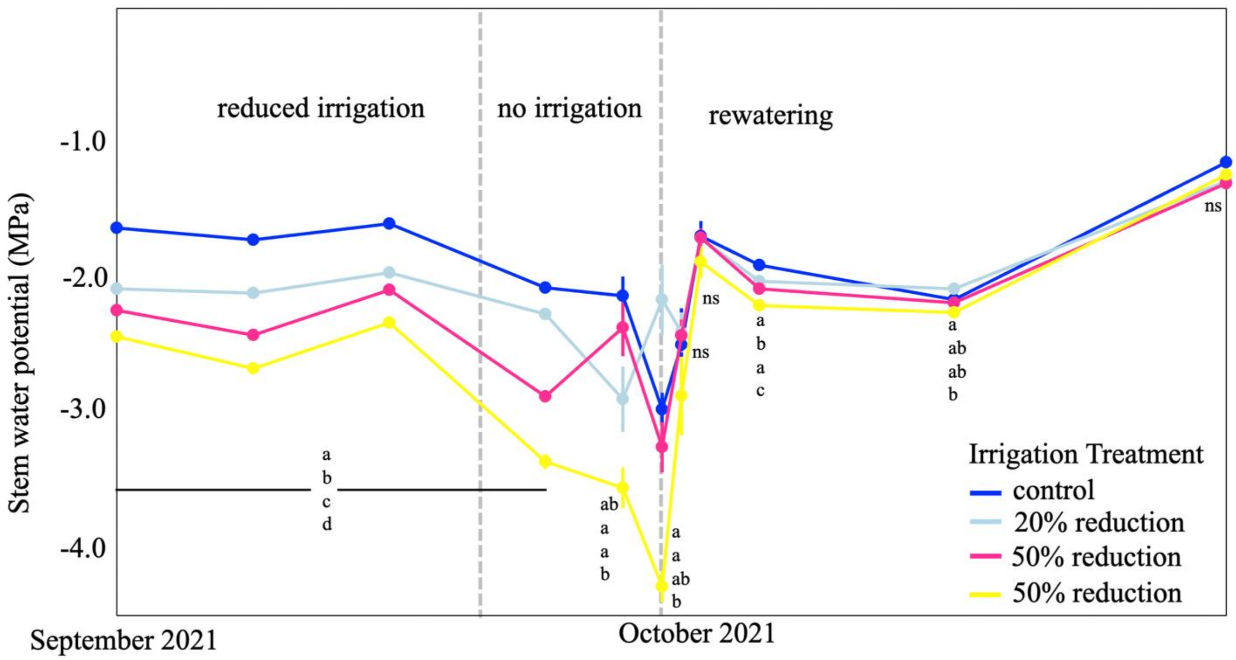

Figure 6. *Detail of the stem water potential (MPa) drop and recovery for the different treatments associated with pre-harvest irrigation reduction. Different letters indicate significant differences among treatments. Ns = non significant*

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. No significant differences were observed among treatments.

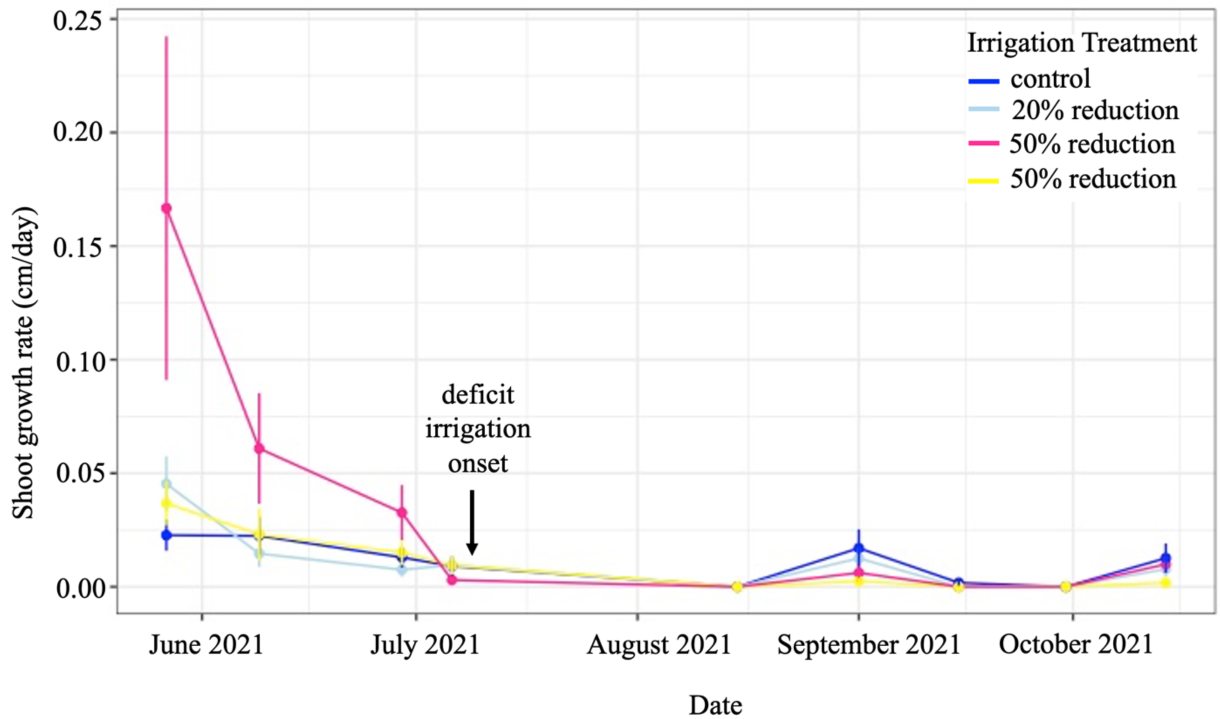

Figure 7. *Vegetative growth rate expressed as cm of new growth per day for the different irrigation treatments through the season. The black arrow represents the beginning of the deficit irrigation treatments.*

Bi-weekly observations showed variations in plant phenology throughout the orchard, but full bloom occurring late April. By late May olives were in development (Fig. 8).

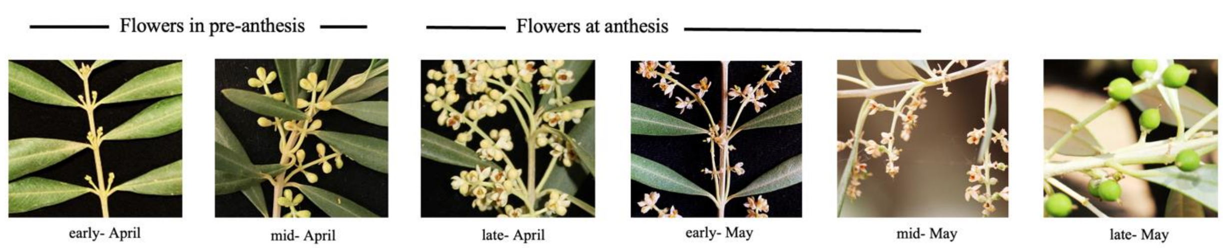

Figure 8. *Stages of olive flower development for the 2021 season*

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. 9). Fruit fresh and dry weight followed this trend (Fig. 10). Pit hardening was also measure and peaked at approx. 55,500 grams force in early August. These data were collected only in the control treatment to characterize fruit phenological development.

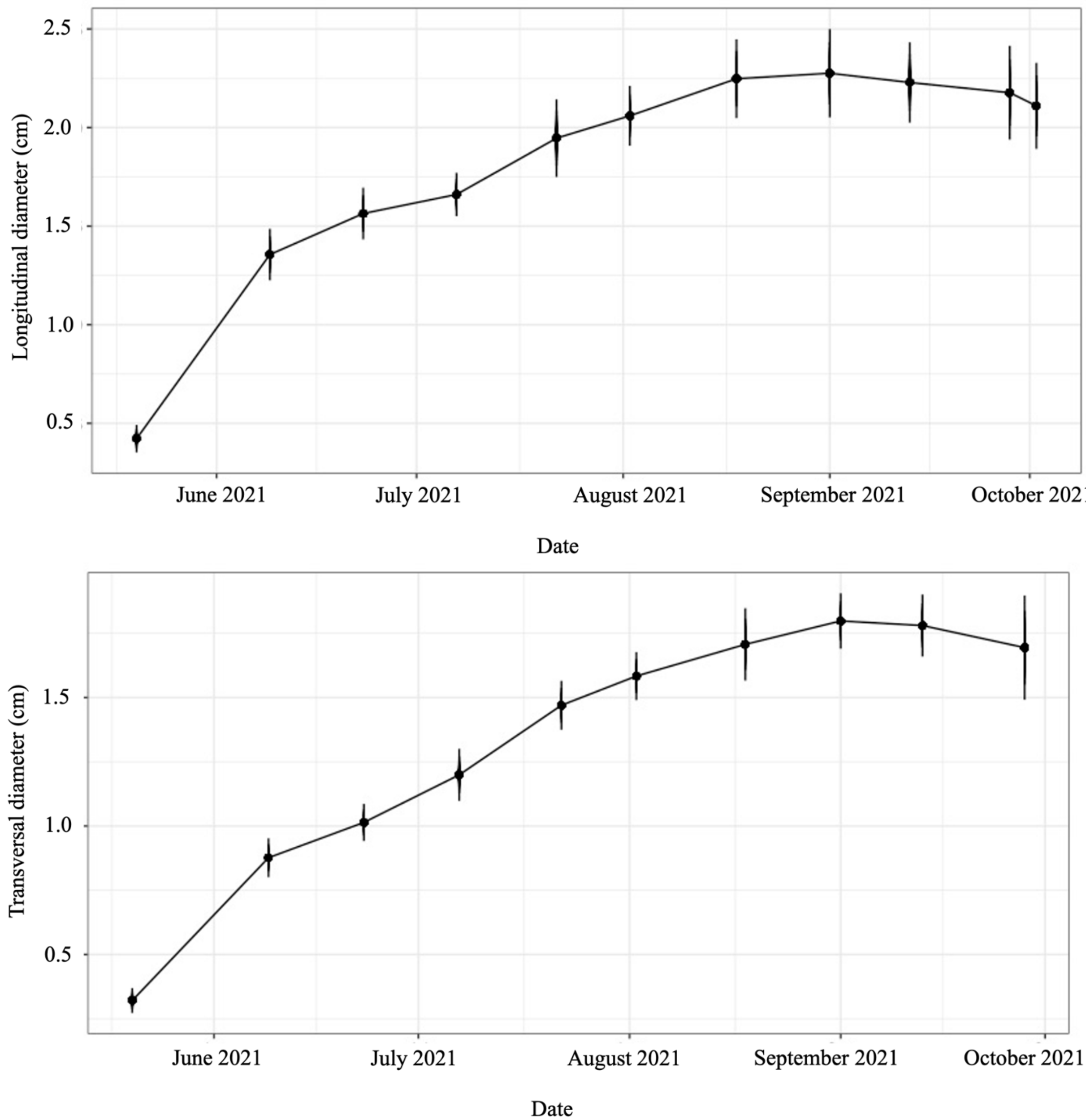

Figure 9. *Longitudinal and transversal dimensions of olive fruits in the control treatment.*

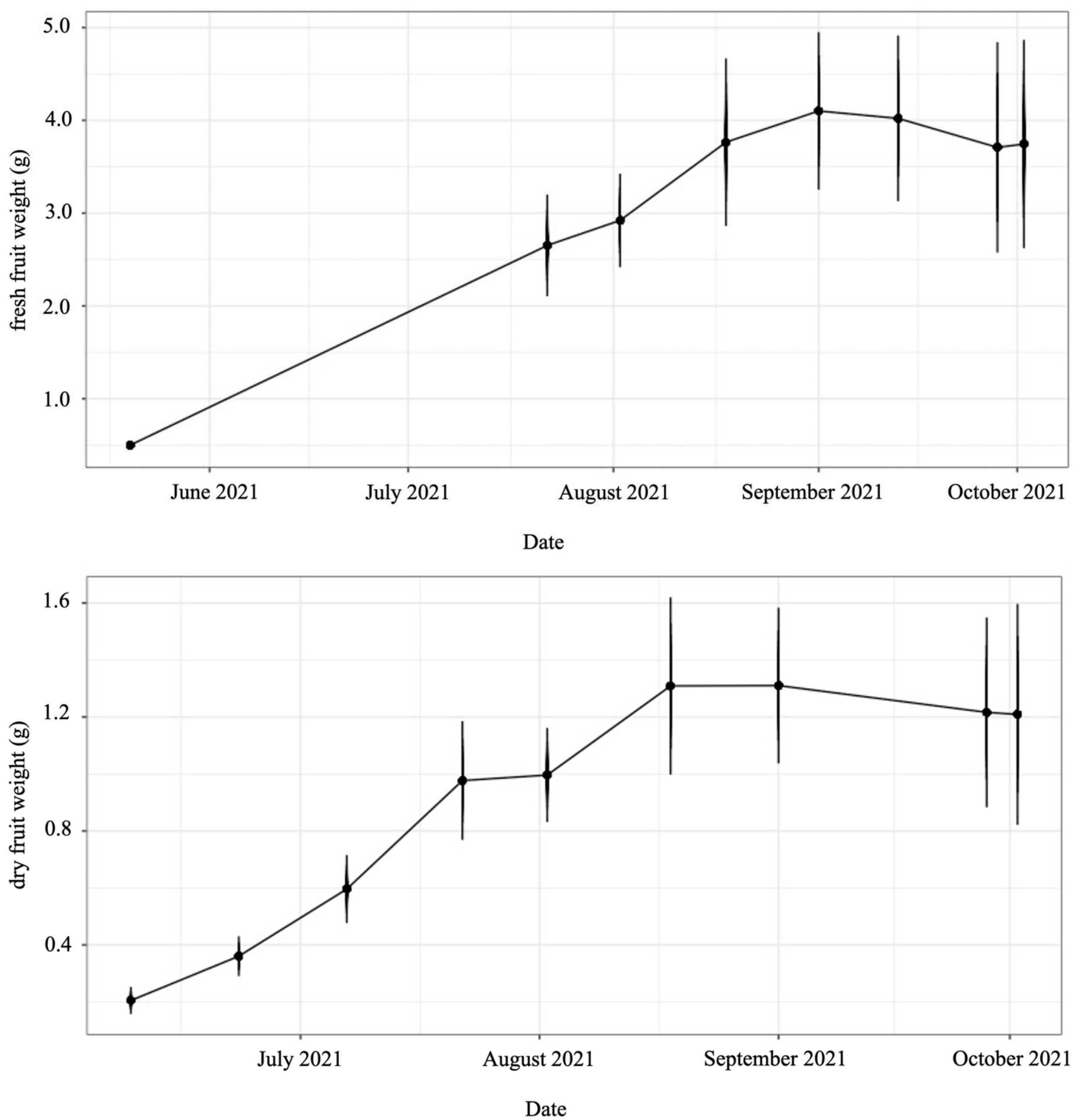

Figure 10. *Fresh and dry weights of olive fruits in the control treatment.*

Mechanical harvest took place on September 28th, 2021. Olives were partially harvested in advance and thus total yield could not be determined. A sample of 60 olives was randomly collected from cumulative harvest bins for each treatment. Fresh fruit was weighed, diameter was taken and volume was measured using displacement method. Fruit moisture content was determined using measurements of fresh and dry weights. A subsample of fruit could not be collected to determine economic value. Olives collected from the 50% reduction treatments had lower fresh fruit weight, longitudinal diameter and smaller mean fruit volume.

Table 1. Summary of 2021 Yield Parameters: Mechanical Harvest

Treatment	Fresh fruit weight (g)	Longitudinal diameter (cm)	Volume (cm^3)	Fruit moisture content (%)
control	3.68[a] ± 0.14	2.17[a] ± 0.04	3.39[a] ± 0.15	66.09[a] ± 0.81
20% reduction	3.52[ab] ± 0.13	2.10[a] ± 0.03	3.35[a] ± 0.13	61.52[b] ± 0.82
50% reduction	2.62[c] ± 0.10	1.96[b] ± 0.03	2.55[b] ± 0.10	57.32[c] ± 0.89
50% reduction	3.10[b] ± 0.13	1.98[b] ± 0.03	2.69[b] ± 0.13	59.14[bc] ± 1.10

Hand harvest took place on October 2nd, 2021. Olives were partially harvested in advance and thus total yield could not be determined. A sample of 60 olives was randomly collected from cumulative harvest piles for each treatment and characterized as done for olives collected during mechanical harvest. A subsample of fruit was collected to determine economic value. Olives collected from the 20% reduction treatments had slightly higher fresh fruit weight, longitudinal diameter and larger mean fruit volume. These differences did not significantly decrease the value of the olives at the grading station.

Table 2. Summary of 2021 Yield Parameters: Hand Harvest

Treatment	Fresh fruit weight (g)	Longitudinal diameter (cm)	Volume (cm^3)	Fruit moisture content (%)	Adjusted value per ton
control	3.77[a] ± 0.13	2.12[a] ± 0.03	3.53[a] ± 0.14	67.25[a] ± 0.85	$1,275.80 ± 15.25
20% reduction	4.44[b] ± 0.16	2.26[b] ± 0.03	4.18[b] ± 0.16	67.01[ab] ± 0.32	$1,273.51 ± 16.67
50% reduction	3.64[a] ± 0.14	2.11[a] ± 0.03	3.47[a] ± 0.16	64.69[b] ± 0.74	$1,222.90 ± 34.51
50% reduction	3.75[a] ± 0.16	2.15[ab] ± 0.04	3.50[a] ± 0.16	61.82[c] ± 0.46	$1,234.65 ± 32.34

In summary, 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 has to be explored further in the coming years since it could impact the crop coefficient and yield. 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: 01/01/2021 – 12/31/2021

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

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

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

1. Problems and Significance

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

Although some olive growers are having some success with trunk shakers, this method has not been widely utilized because the willowy olive trees growth habit prevents the effective transmission of vibrational energy from the trunk to the small distal branches where the fruit is located. To remove fruit with a trunk shaker requires a large amount of energy and extended duration, which can cause tree damage. Also, for some older orchards, the trunk shaker may not be an option due to the size and shape of the trunk and/or canopy.

Engineers at UC Davis developed a prototype canopy contact shaker that was tested with some success and which was very similar to the canopy shaker used to harvest Florida juice oranges. Ehsani’s group at UC Merced used an alternative design to develop a 50% lighter canopy contact shaker-based fruit removal system that can accommodate larger trees. This system has shown

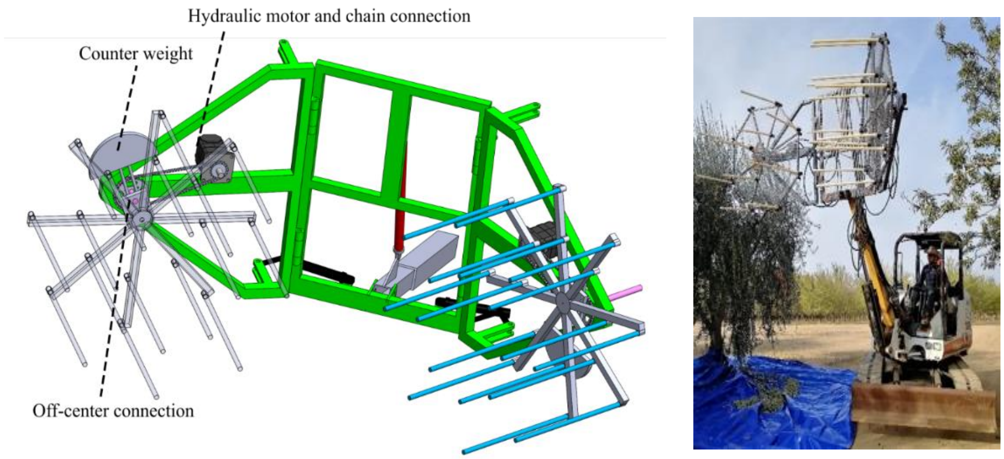

Figure.1 UC Merced fruit removal canopy shaking head.

(a) (b)

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

promising results as well. The UC Merced design was able to produce the maximum shaking energy at the fruit level as opposed to the trunk, and hence, less damage to the tree. However, it took a long time to shake each tree.

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

This word is the continuation of a previously funded COC project. Figure.1 shows the UC Merced canopy shaker fruit removal system. The UC Merced-designed canopy shaker was tested in 2018, 2019 and 2020

2. Objectives:

- Study effect of a larger canopy shaker on old and large olive trees.
- To disseminate the integrated knowledge gained through this research.

3. Experimental Procedures:

To achieve the objectives of the proposed project, the following specific tasks are planned to be done:

Task 1- To 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 (Figure.3).

Task 2- Conduct a series of field tests at one of the collaborating growers to evaluate the performance of the newly designed canopy shaker and use the data to estimate the total yield.

4. New Shaker Machine

The new canopy shaker was built in Ehsani's Lab (Figure.4). The new canopy shaker head has a rectangular shape with a height of 8ft and a 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.

Shaker head has been installed on a Bobcat 337. Figure.5 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.

5. Experimental Procedure

This shaker machine was tested in an olive orchard on September 23rd, 2021. The sample trees were topped at 12 and 14 feet in March 2021 by the orchard owner. Four trees were randomly selected from each height category for this experiment. Tarps were used to collect the mechanically harvested fruit. A sample from each tree was sent to a grading lab to get fruit quality data.

An experienced olive harvesting gleaning crew was hired to harvest the fruit remaining on the trees. The manually harvested fruit was weighed and recorded. Harvest efficiency was calculated using equation (1).

$$Efficiency = \frac{Mechanically\ harvested\ (lb)}{Manually\ harvested\ (lb) + Mechanically\ harvested\ (lb)} \times 100 \quad (1)$$

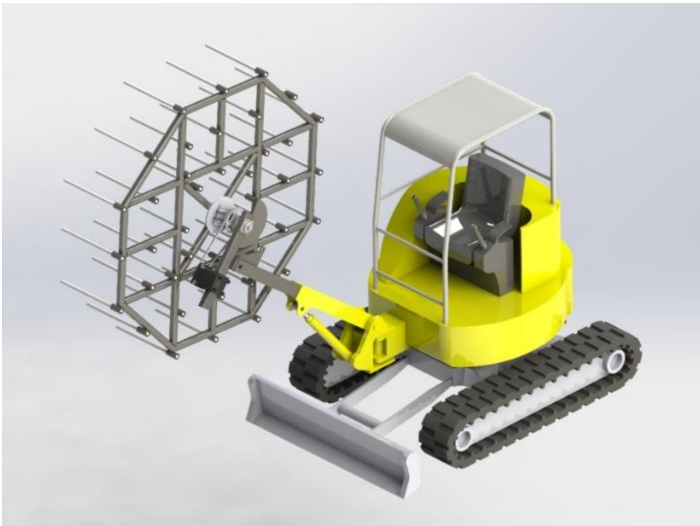

Figure.3 Proposed shaker design that includes a side-mounted canopy shaker.

4

Figure.4 Newly designed canopy shaker built for old large olive trees in California.

Figure.5 Internal mechanism used to generate circular oscillation movement in the canopy shaker.

5

6. Results

Table 1 shows the weight of the fruits harvested by the canopy shaker and what was harvested by the gleaning crew. It also shows the harvest efficiency of each individual tree.
Figure.6 shows the average harvest efficiency for each category and an average of all the trees.

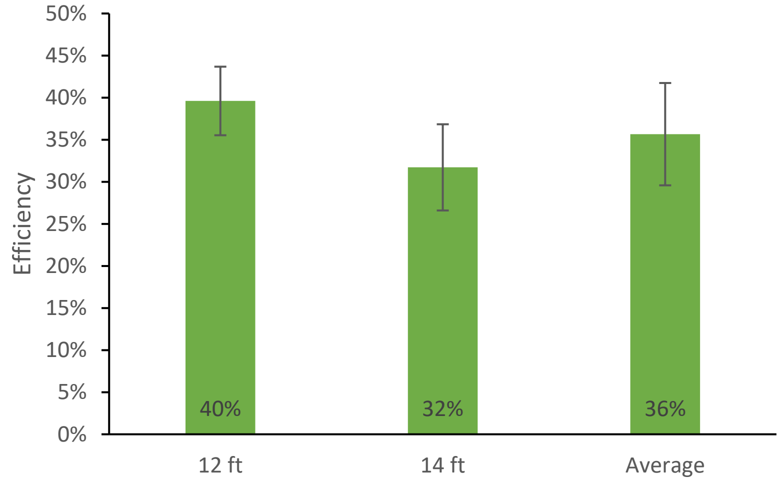

Figure.6 Harvest efficiency of trees topped at 12, 14 feet and an average of both.

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%

A grading lab has evaluated the quality of harvested fruits, and the results are shown in Figure 7. In both samples quality of fruits harvested by the canopy shaker has been higher than the remaining fruits, which have been harvested manually. On the other hand, the overall fruit quality of olive trees with 14ft canopy was higher than the trees with 12ft canopy. This is partly due to the size of fruits harvested from the shorter trees. Figure 8 shows the distribution of harvested fruit size from each trial. It shows that shorter trees have produced more sub-petite and undersize fruits compared to the taller trees, this is the main reason the price of the fruit harvested from shorter trees has been lower.

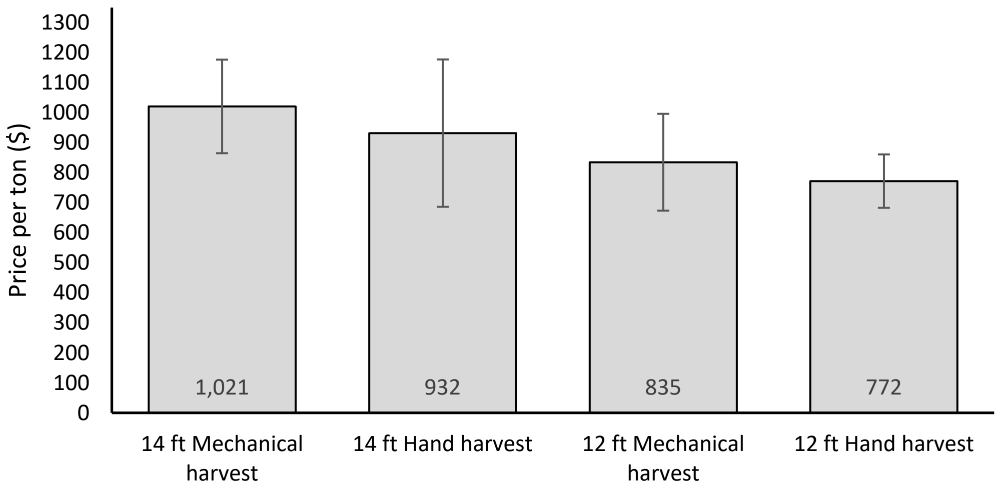

Figure 7 Fruit quality results obtained from a grading lab.

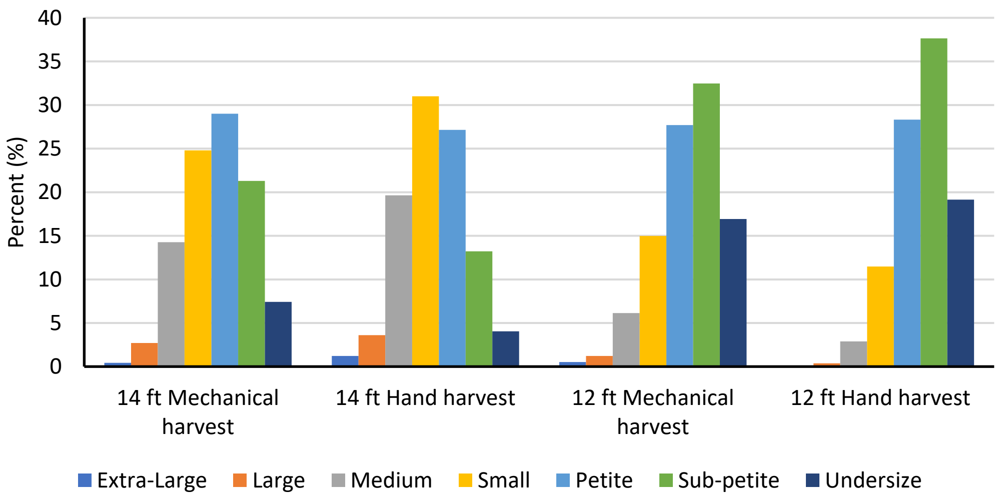

Figure 8 Fruit size distribution from each trial.

7. Conclusion

A modified canopy shaker design was conceptualized and built based on field observation (Figure.3). The new system has a very simple design and can be built by any local shop. Also, it is an attachment that can be installed on a commercially available small excavator. This can reduce the cost of the system significantly. The new side-mounted canopy shaker is designed for bigger old 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 shaking head was able to remove most of the fruits where it rods contacted the canopy. The low harvest efficiency was mostly due to the lack of adjustability of the shaking head itself. We plan to address this in our next design. On the other hand, the harvested fruits showed some degree of damage and bruise; however, the grading results from the processing plant didn't show this issue as an adverse effect on the quality/price of harvested fruits. In addition, the branch shaker used in the experiment needed some reinforcement to improve its reliability. Limiting the height of trees and pruning them close to the ground lower branches can also improve the efficiency and speed of harvesting.

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 have padding on them to reduce damage during the harvest.

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ANNUAL REPORT - 2021
California Olive Committee (COC) and California Olive Oil Committee (COOC)

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

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

Institution: Department of Microbiology and Plant Pathology, University of California, Riverside, CA 92521

Introduction

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 phytotoxicity when applied as an air-blast foliar treatment. Copper has been extensively used in olive production for many years for the control 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, and other alternatives need to be evaluated.

Over several years of studies, we found kasugamycin to be the most effective new treatment for preventing olive knot (11). The antimicrobial was highly effective in controlling olive knot on naturally formed leaf scars and wounds created by hedging or harvesting. Kasugamycin was first federally registered on pome fruits, followed by registrations on cherry and walnut. Registration on peaches and almonds is pending for late 2021. The olive submission of kasugamycin to the EPA was in late summer of 2020 because new residue trials and laboratory analyses were needed and were completed in 2019. Kasugamycin would greatly complement current copper sprays and could be used in rotation or mixtures with copper. Oxytetracycline is also pursued for registration through the IR-4 program. It was also submitted in late summer 2020, and registrations of both are expected to be simultaneous. We plan to conduct additional studies with oxytetracycline and kasugamycin to potentially improve use of these antibiotics by adding reduced rates of copper or food-grade antimicrobials (nisin and ε-poly-L-lysine) that are exempt from tolerance to protect wounds until they heal. The fungicide dodine has been reported to have bactericidal properties when used at high labeled rates. Since this compound is being registered for peacock spot, we plan to evaluate it as a bactericide alone or in combination with other antimicrobials (i.e., copper, antibiotics, and food-grade antimicrobials).

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

Objectives

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

a) Laboratory in-vitro sensitivity studies: nisin, Ɛ-poly-L-lysine, mixed with the sanitizers lactic acid or capric/caprylic acids (Dart) alone or combination and in mixtures with selected adjuvants (to improve field stability), as well as dodine as a bactericide (since it is being registered as a fungicide on olive).

b) Field efficacy studies with new bactericides in comparison with kasugamycin for the management of olive knot caused by copper-sensitive and -resistant strains of *Psv*.

i) Oxytetracycline and kasugamycin formulations in combination with selected adjuvants (e.g., Dart) or low rates of copper in traditional (e.g., Kocide, Champ) and new formulations (e.g., Cueva) with inherent low copper concentrations as compared to traditional products.

ii) Nisin, Ɛ-poly-L-lysine, Dart, and dodine alone, in combination with each other, or in mixtures with antimicrobial acids (e.g., lactic, citric, and capric/caprylic).

3) Continue to support the registration of the antibiotics kasugamycin and oxytetracycline

a) Support letters for both antibiotics from myself and the industry (COC) were provided in the fall of 2020 to IR-4 for inclusion to the IR-4/registrant (UPL for kasugamycin and AgroSource for oxytetracycline) submission petition to EPA.

b) Optimizing the efficacy of oxytetracycline, kasugamycin, and dodine under field conditions as they go through the final registration process on olives to ensure guidelines can be provided to the industry for optimal performance.

Plans and Procedures

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

a. To determine the in vitro toxicity of new bactericides, different methods were used depending on the formulation of the compound and its toxicity. Amended agar studies where the pathogen was in continuous contact with the test substance were used for Dart and ningnanmycin (i.e., the spiral gradient endpoint assay) and for ningnanmycin, ET-91, and QAM (i.e., the agar dilution method). Direct exposure studies where the pathogen was exposed to the test substance for a limited time (60 min) and was then plated onto non-amended agar were done using BacStop.

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

2) Continue to support the registration of the antibiotics kasugamycin and oxytetracycline. An inter-commodity and industry group continued to work with the Minor Crop Farmer Alliance to recommend an EPA policy change towards the use of antibiotics in plant agriculture. Additionally, we continued to work with a USDA working group to address CODEX initiatives for establishing policies on all antibiotic use in agriculture including animal and plant uses. We attend the IR-4 Food Use Workshop and meet with EPA to discuss the registration status of all submissions including kasugamycin, oxytetracycline, and other materials such as dodine.

Results and Discussion

Toxicity and efficacy of new bactericides against *Psv*. Among compounds evaluated, the natural antibiotic ningnanmycin most effectively inhibited growth of *Psv* (Table 1). Using the agar dilution method, growth was almost completely inhibited by 10 ppm, and no growth was present at 50 ppm. Using the spiral gradient dilution method, an MIC of 7 ppm was determined. The MIC of the agave extract QAM was 100 ppm, and that of the capric/caprylic acid mixture Dart was approximately 500 ppm. The essential oil products ET-91 and BacStop did not inhibit growth of *Psv* at 5000 ppm and 1000 ppm, respectively. Some of these compounds were included in field efficacy studies with data presented below or data pending in 2022. These latter products may be inducing a systemic acquired resistance responses in the host plant. Therefore, field evaluations are required.

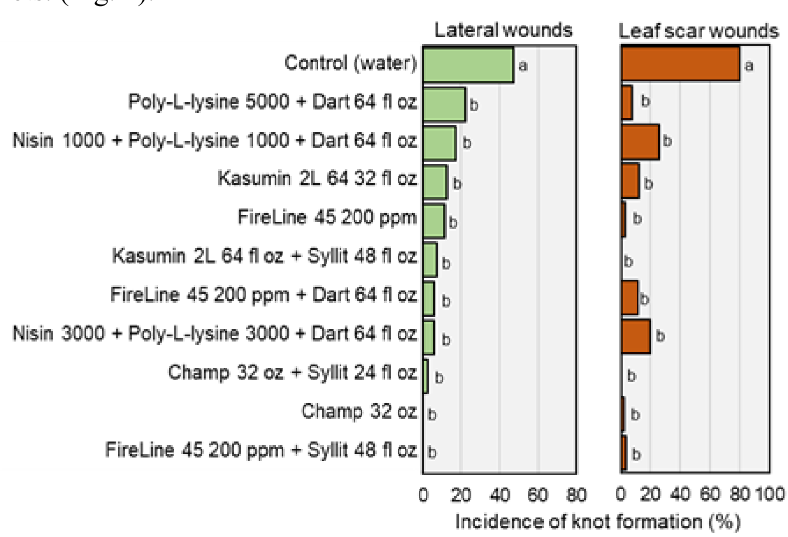
Table 1. Summary of in vitro toxicity studies with *P. savastanoi* pv. *savastanoi* using new antimicrobial compounds

Compound	Type of compound	Inhibition of growth	Assay used
BacStop	Essential oils	No inhibition at 1000 ppm	Direct exposure 60 min
Capric/caprylic acids (Dart)	Natural acids	MIC ca. 500 ppm	Spiral gradient endpoint assay
ET-91	Essential oils	No inhibition at 5000 ppm	Agar dilution method
Ningnanmycin (Ninja)	Natural antibiotic of *Streptomyces noursei* var. *xichangensis*	MIC = 50 ppm	Agar dilution method
		MIC = 7 ppm	Spiral gradient endpoint assay
QAM	Agave extract	MIC = 100 ppm	Agar dilution method

Several greenhouse (Fig. 1) and field efficacy (Fig. 2 and 3) studies were conducted using new bactericides by themselves or in selected mixtures, and efficacy was compared to copper, kasugamycin (Kasumin), and Kasumin-copper mixtures. Additional studies that were initiated in the fall of 2021 are ongoing. As in previous years, differences in efficacy were sometimes observed for protecting lateral wounds and artificially created leaf scar wounds (leaves were pulled off).

In the greenhouse study, all treatments significantly reduced olive knot for lateral wounds and leaf scar injuries as compared to the control (Fig. 1). The treatments with the lowest incidence of disease were Champ, Kasumin+Syllit, FireLine+Syllit, and Champ+Syllit for both lateral wounds and leaf scar injuries. Syllit (i.e., dodine) has bactericidal properties and its mixture with copper or the antibiotics numerically enhanced the performance of these treatments. Still, FireLine and Kasumin were also effective as solo treatments. The food preservatives nisin and ε-poly-L-lysine were more variable in their performance on the different types of injuries, but still effectively reduced the development of knots. (Fig. 1).

Fig. 1. Evaluation of new bactericides for management of olive knot of cv. Arbequina after inoculation with a Cu-sensitive strain of *Psv* - Greenhouse study at UC Riverside



*- Olive twigs were wounded by lateral wounds, or leaves were removed in mid-Dec. 2020. Wounds were treated by hand-spraying until runoff. After air-drying, wounds were inoculated with a copper-sensitive strain of Psv ($2x10^7$ cfu/ml). Twigs were evaluated for knot development in mid-July 2021.

In field studies on Arbequina at UC Riverside, Kasumin-Syllit, Kasumin-Badge (copper), FireLine+Syllit, and the mixture of Nisin and ε-poly-L-lysine with Dart continued to be highly effective on lateral injuries and leaf scars (Fig. 2). Kasumin mixed with dodine (i.e., Syllit) was highly effective and numerically had lower incidence on lateral wounds and was similar to Kasumin+Badge (copper). FireLine, an oxytetracycline product used alone or in mixtures with Dart or Syllit was also highly effective in this trial. The antibiotic Ninja was not significantly different from the untreated control (Fig. 2). Mixtures of ε-poly-L-lysine and Dart but not Nisin and Dart were efficacious on both types of wounds.

Fig. 2. Evaluation of new bactericides for management of olive knot of cv. Arbequina after inoculation with a Cu-sensitive strain - Field trial at UC Riverside

1- Olive twigs were wounded by lateral wounds, or leaves were removed in April 2021. Wounds were treated by hand-spraying until runoff. After air-drying, wounds were inoculated with a copper-sensitive strain of Psv ($2x10^7$ cfu/ml). Twigs were evaluated for knot development in Nov.

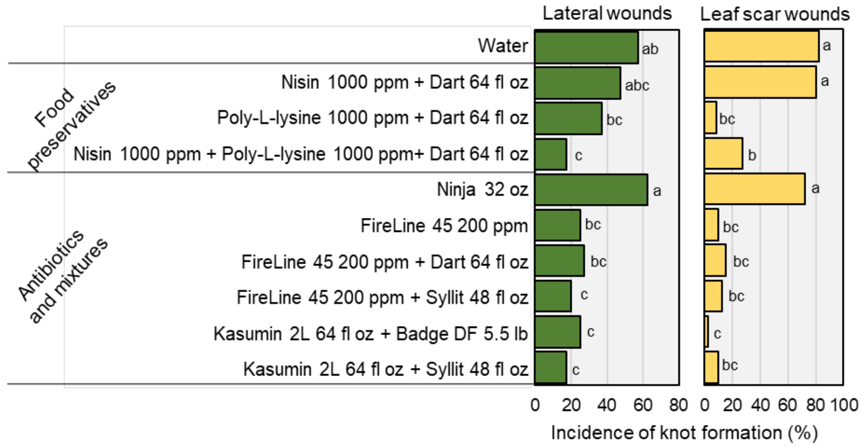
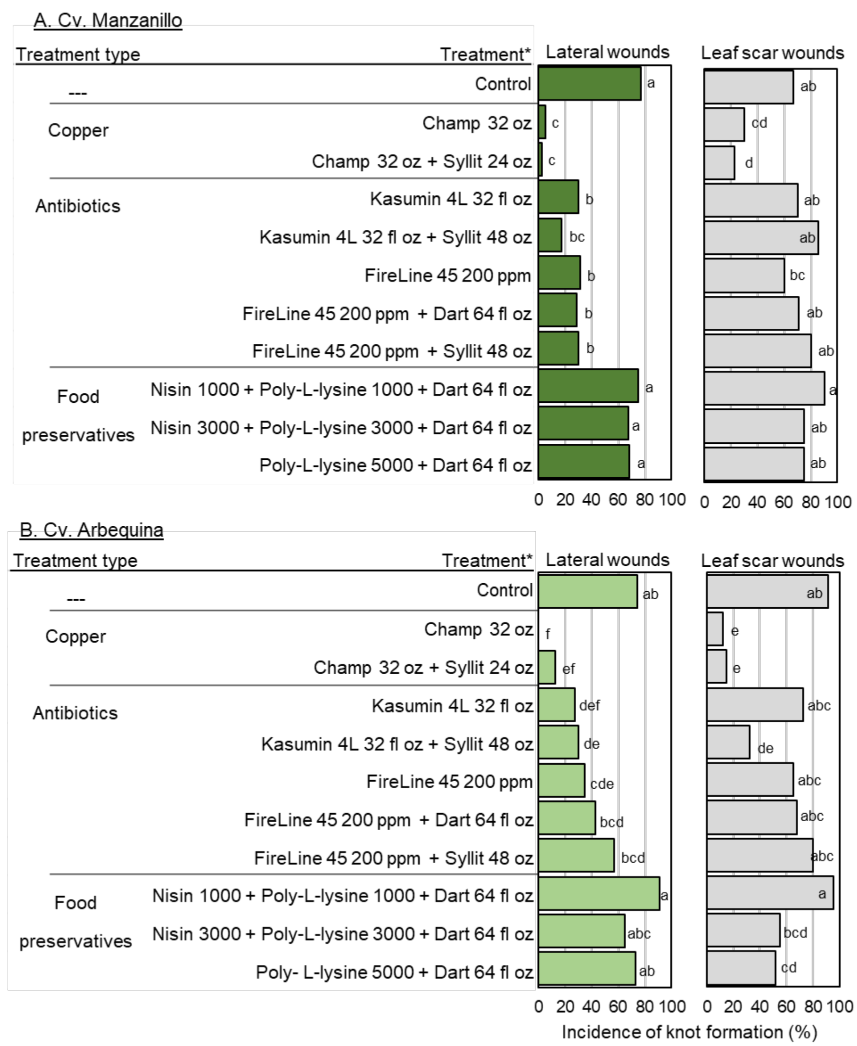


Fig. 3. Evaluation of new bactericides for management of olive knot after inoculation with a Cu-sensitive strain - Field trials at UC Davis

Olive twigs were wounded by lateral wounds, or leaves were removed in Nov 2020. Wounds were treated by hand-spraying until runoff. After air-drying, wounds were inoculated with a copper-sensitive strain of Psv ($2x10^7$ cfu/ml). Twigs were evaluated for knot development in Sept. 2021.



In field trials on cvs. Manzanillo and Arbequina at UC Davis, Champ and Champ+Syllit performed extremely well, and knot formation was significantly reduced from the control for both lateral and leaf scar wounds (Fig. 3A, B). Kasumin+Syllit was statistically similar in efficacy to most of the copper treatments, significantly reducing knot incidence on lateral wounds and leaf scars on cv. Arbequina, but only lateral wounds on cv. Manzanillo. Among other antibiotic treatments, Kasumin alone, FireLine alone, or either of these antibiotics in mixtures with Dart or Syllit resulted in a significantly lower incidence of knot on lateral wounds (but mostly not on leaf scar wounds) than the untreated control. They were, however, mostly less effective than copper treatments on both cultivars (Fig. 3A,B). In this study, the food preservatives were not effective in reducing knot on both types of wounds on the two cultivars.

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. Dodine is also a fungicide and is effective against olive leaf spot. Therefore, its registration on olive will allow for mixtures with copper or antibiotics for the management of olive leaf spot and knot.

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 Dec. 2021, but now it has changed again 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 to EPA 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.

ANNUAL REPORT - 2021
California Olive Committee (COC) and California Olive Oil Committee (COOC)

Project title: Evaluation of new fungicides for control of olive leaf spot

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

Institution: Department of Microbiology and Plant Pathology, University of California, Riverside, CA 92521

Introduction

Olive leaf spot or peacock spot, caused by the fungus *Fusicladium oleagineum* (syn. *Spilocea oleaginea,_Venturia oleaginea*), is a common disease of olive trees in California but only sporadically occurs at high incidence. 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. The disease cycle is shown in Fig. 1. 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, dark blotches. Later they become circular and dark green to black and contain mycelium and conidia (Fig. 1), and they are surrounded by yellow halos. These lesions resemble the spots on the tail of a peacock, and hence the name peacock spot. The cuticle may separate to cause a silvery lesion. With numerous lesions, the leaf becomes chlorotic and falls.

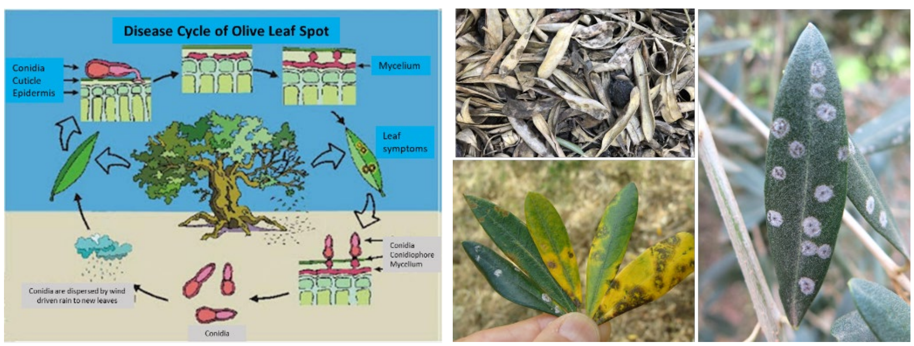


Fig. 1. Disease cycle and symptoms of Peacock spot caused by *Fusicladium oleagineum.* Left: Disease cycle; Middle-top: Symptoms on fallen leaves (Fall-Winter); Middle bottom: Range of symptoms on leaves (Spring); Right: Silver lesions from cuticle separation from epidermis (Early summer).

Leaves in the lower canopy where the humidity is higher are more severely affected, resulting in more severe 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 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 mechanisms of dissemination of conidia (Fig. 2), 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 21ºC, but growth can occur at 6 to 28ºC. The minimum duration of leaf wetness for spore germination is 48 h at 16ºC, 24 h at 20ºC, or 36 h at 24ºC. The incubation period is 12 to 19 days over a temperature range of 10ºC to 25ºC.

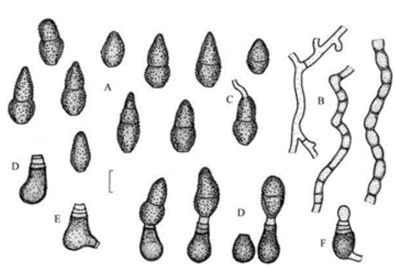


Fig. 2. *Fusicladium oleagineum.*
A - conidia. B - superficial septate hyphae, C - germinating conidium, D - conidiogenous cells with several conspicuous annellations, E – percurrent proliferating conidiogenous cell, F - conidiogenous cell arising from a hypha. Scale = 10 µm.

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, and 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 (FCs) M3, 3/9, 3/11, and U12, respectively. Thus, integration of multi-site MOA with single-site MOA products is planned to establish an effective anti-resistance strategy. Residue trials were conducted in 2019/20, and laboratory analyses were done in 2021 for the first two fungicides. Research on these and newly identified fungicides needs to continue to provide efficacy data for several years and to develop use strategies (i.e., timing, adjuvants).

Objectives

1. **Evaluate the performance of new and older fungicides in field trials.**
   a) Multisite MOA fungicides - Dithiocarbamates (ziram) (FRAC Code – M3)
   b) Single-site MOA fungicides – DMIs (e.g., difenoconazole) pre-mixed with other fungicides like cyprodinil (Inspire Super - FC 3/9) or 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) Fall, spring, or fall and spring
   b) Adjuvants: NuFilm-17, capric/caprylic acids, oil
3. **Evaluate new fungicides for their in vitro activity.**
   a) Determine the in vitro activity of selected fungicides that are effective in field trials.

Plans and Procedures

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

2. *Evaluate application timing and adjuvants for selected treatments.* Field applications were planned of selected fungicides at different timings to compare fall vs. spring or fall + spring timings. A standard adjuvant such as Nu-Film 17 was used for all treatments. There were four replications for each treatment in a randomized complete block design for a factorial experiment. Disease incidence and severity were evaluated in late spring. Data were analyzed statistically using ANOVA procedures and mean separation procedures of SAS 9.4.

3. *Evaluate new fungicides for their in vitro activity.* Isolates of the pathogen were obtained from several locations. To evaluate the in vitro toxicity of selected new fungicides, a new method was developed for spore germination studies. Spores were plated onto media amended with fungicides at selected concentrations, and germination was assessed after 24-36 hours at 20 C. Suspensions of spores from infected leaves or cultures were used.

Results and Discussion

Evaluate the performance of new and older fungicides in field trials and application timing of selected treatments. Ziram (dithiocarbamate - FC M3), Ph-D (polyoxin-D - FC 19), Syllit (dodine-FC U12), Abound (azoxystrobin-FC 11), the pre-mixtures Inspire Super (difenoconazole-cyprodinil- FC 3/9) and Quadris Top (difenoconazole/azoxystrobin - FC 3/11), and tank mixtures of Ph-D and Syllit, as well as of ziram and copper were compared to copper as a standard treatment on cvs. Manzanillo and Arbequina in three field trials in Glenn and Sutter (Table 1), as well as Yolo Co. (Table 2). Treatments were applied in the fall (Nov. 2020) and were evaluated in April/May 2021 for peacock spot leaf symptoms. All treatments significantly reduced the disease from the control. Abound, Inspire Super, Ph-D, Quadris Top, Syllit, and the Syllit-Ph-D tank mixture were the most effective in these trials on the two cultivars and at the three locations. Ph-D was also highly effective in our 2019, 2020, and 2021 trials, and the registrant UPL has agreed to add olive to the label.

Table 1. Efficacy of fungicide treatments for management of peacock spot of Manzanillo and Arbequina olive, Glenn and Sutter Co. 2020-21.

				Manzanillo Glenn Co.		Arbequina Sutter Co.	
			Application	Infections		Infections	
No.	Treatments*	Product rate/A	11-6-20	No.	LSD	No.	LSD
1	Control	---	---	35.8	a	35.0	a
2	Ziram	128 oz	@	15.3	b	8.0	b
3	Abound	12.5 fl oz	@	12.5	bc	not done	
4	Champ	96 oz	@	11.8	bc	9.5	b
5	Syllit + Ph-D	32 + 6.2 oz	@	11.5	bc	8.5	b
6	Ziram + Champ	80 oz + 80 oz	@	11.0	bc	12.8	b
7	Syllit	48 oz	@	9.8	bc	7.5	b
8	Quadris Top	14 fl oz	@	9.8	bc	7.8	b
9	Ph-D	6.2 oz	@	7.0	bc	12.3	b
10	Inspire Super	20 fl oz	@	5.5	c	8.5	b

[1] - Treatments were applied with a sticker using an air-blast sprayer at 100 gal/A.
[2]- Disease was evaluated on 4-28-21 and 100 random leaves of each tree were assessed for the presence of typical disease symptoms.

Table 2. Efficacy of fungicide treatments for management of peacock spot of Manzanillo and Arbequina olive, Solano Co. 2020-21.

					Arbequina Infections		Manzanillo Infections	
No.	Treatments*	Product rate/A	Nufilm-P	Application 11-5-20	No.	LSD	No.	LSD
1	Control	---	---	---	83.7	a	54.3	a
2	Ziram	128 oz	12 fl oz	@	29.5	b	18.3	b
3	Quadris Top	14 fl oz	12 fl oz	@	28.3	b	20.8	b
4	Syllit	48 oz	12 fl oz	@	26.8	b	20.5	b
5	Champ	96 oz	12 fl oz	@	21.8	b	16.8	b
6	Inspire Super	20 fl oz	12 fl oz	@	21.0	b	16.5	b
7	Ph-D	6.2 oz	12 fl oz	@	20.5	b	14.8	b
8	Syllit + Ph-D	32 + 6.2 oz	12 fl oz	@	18.0	b	16.0	b
9	Abound	12.5 fl oz	12 fl oz	@	13.3	b	14.5	b

[1] - Treatments were applied with a sticker using an air-blast sprayer at 100 gal/A.
[2]- Disease was evaluated on 5-5-21 and 100 random leaves of each paired trees were assessed for the presence of typical disease symptoms.

Evaluate application timing of selected treatments. Timing studies were not done due to low rainfall in the winter of 2021. Only a single application was made on Nov. 5 in Solano Co. and on Nov. 6 in the Glenn and Sutter Co. trials.

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 (i.e., winter and early spring) under California conditions. Moreover, under low rainfall conditions, sporulation is low. Spore germination assays in the presence of fungicides are ongoing.

IR-4 GLP Studies (Registration update). In 2021, we reviewed protocols, and we are assisting in field studies that are ongoing. Ziram, Inspire Super, and Quadris Top are currently in the system, and GLP field residue studies were conducted for these fungicides in 2020-21. We 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 submitted for a concurrent review with the state of California. Syllit is currently registered on pome fruit and almond in California. Five fungicides, Ziram, Inspire Super, Quadris Top, Ph-D, and Syllit, are planned for full registration for managing Peacock spot of olive. Usage strategies as “after harvest”, dormant, and springtime use before flowering will ensure extremely low to zero detections of fungicide residues at harvest and maintain the high quality of California olives.

Final 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 of 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's table olive industry, thus towards efficiency of mechanical harvesting efforts have been made to optimize tree shape 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 that lignin deposition takes 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 studied 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, September16th) 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 were 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 a light microscope. The same 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. Fuchsin staining was performed with ClearSee method (Ursache et al., 2018). 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**.

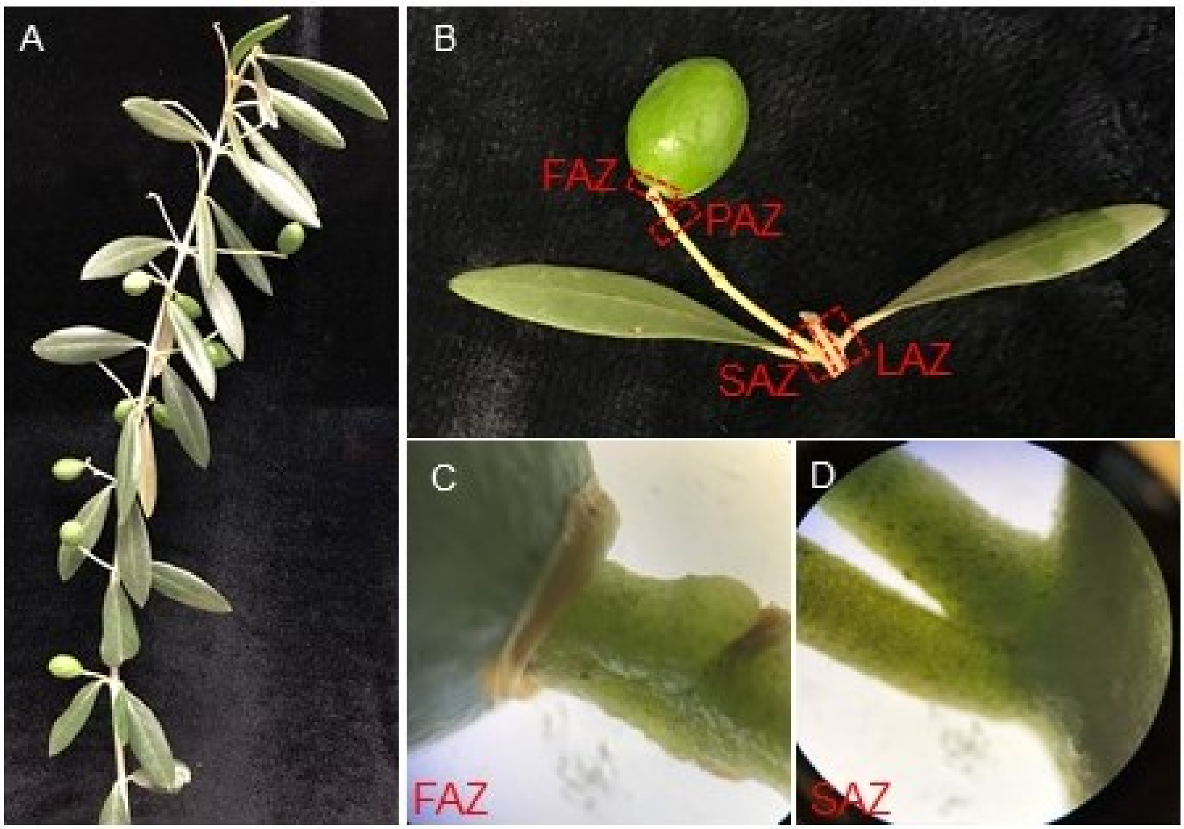


Figure 1. Illustration of regions to monitor. (A) Fruiting branch. (B) Red dashed line indicates potential abscission zones monitored through the season, fruit abscission zone (FAZ), peduncle abscission zone (PAZ), secondary abscission zone (SAZ), and leaf abscission zone (LAZ). (C) Enlargement of fruit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

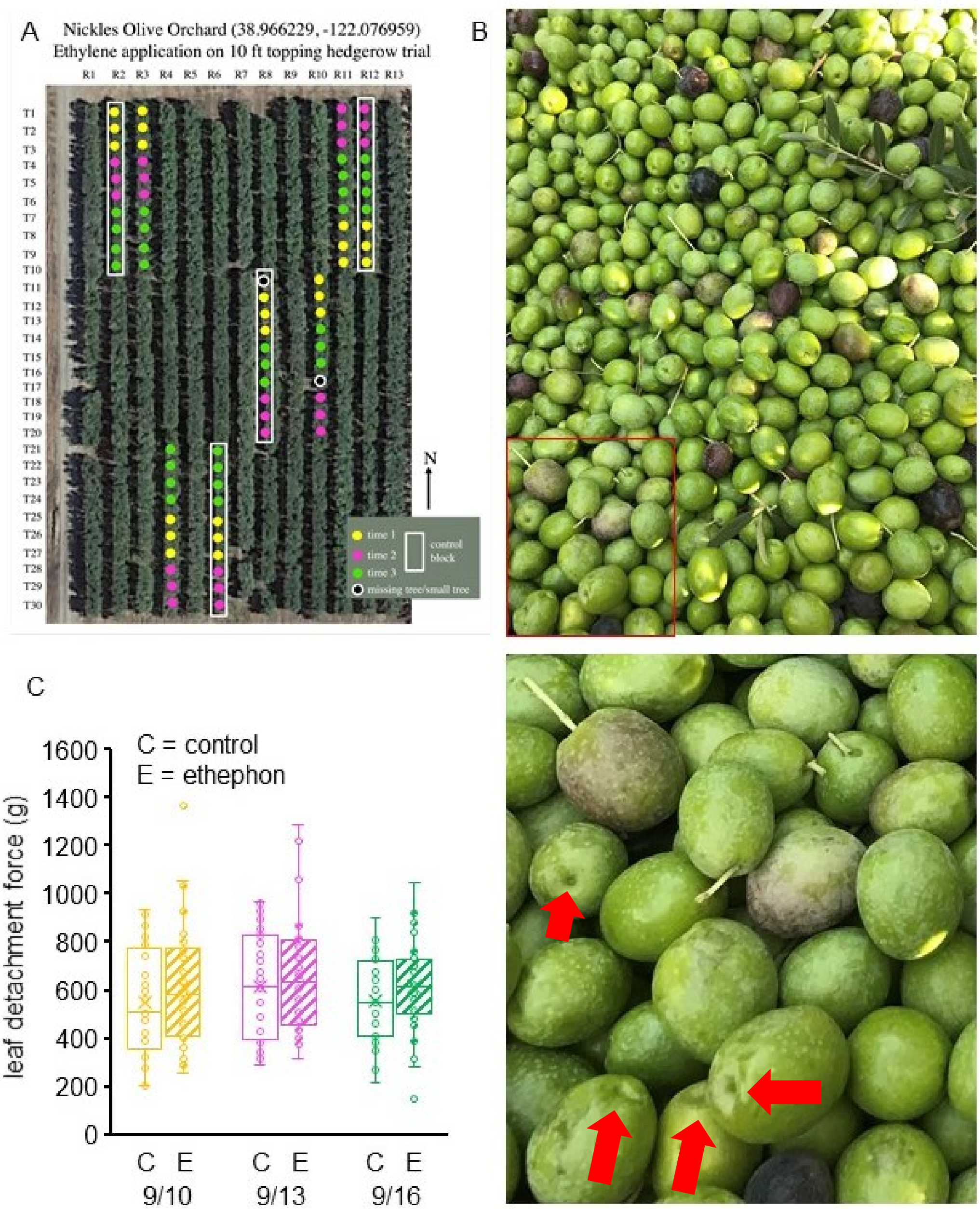


Figure 2. Ethephon treatment for mechanical harvesting of table olives. (A) Ethephon and water application plan before harvest (coordinated with Ferguson Lab). (B) The majority of fruit detachment from the tree occurs at the fruit abscission zone (FAZ) during mechanical harvest, with red rectangular 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 predicted abscission zone sites.

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).

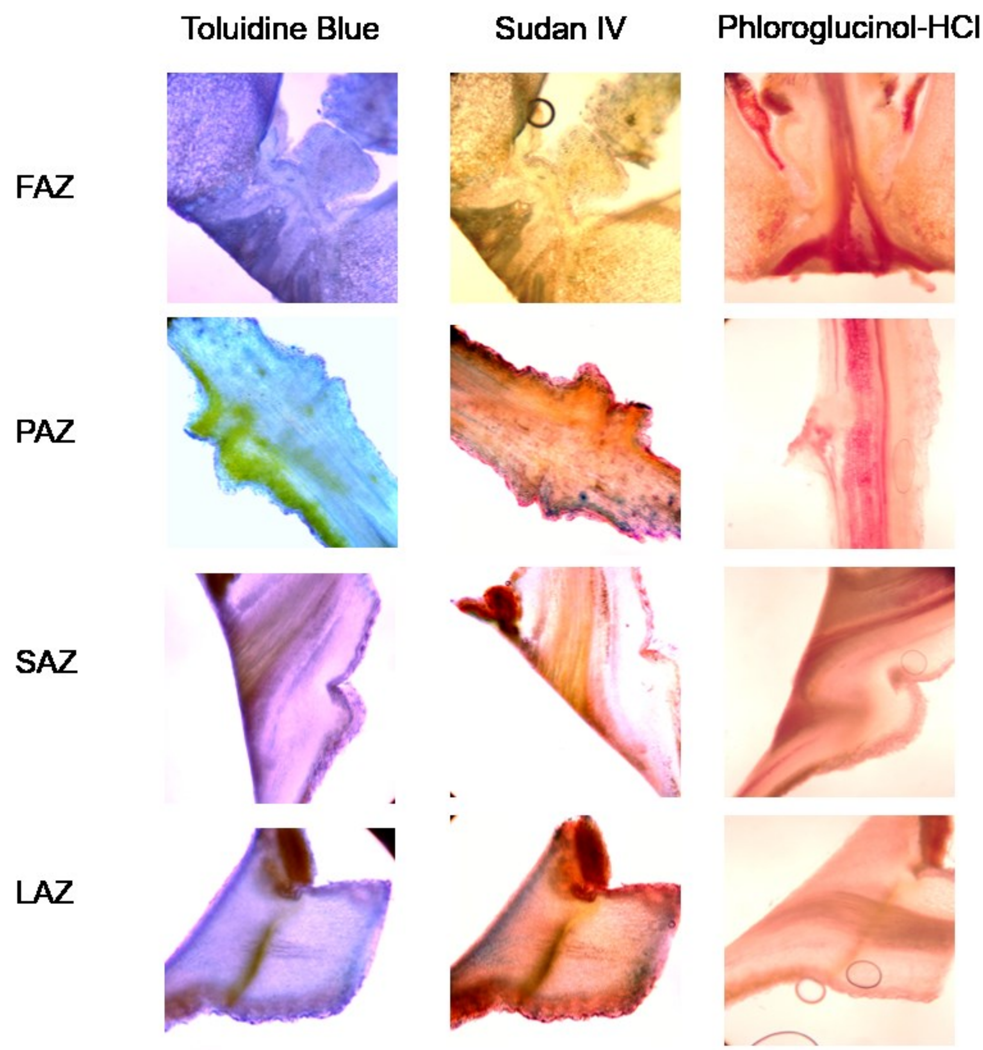


Figure 3. Toluidine blue, Sudan IV, phloroglucinol-HCl staining of all potential abscission zones of untreated samples from 18-week post-anthesis fruit branches. (25X, bright view).

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

On the day of harvest, September 22[th], 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, with enlargement of lignified cells shown in a separate panel (**Figure 6**).

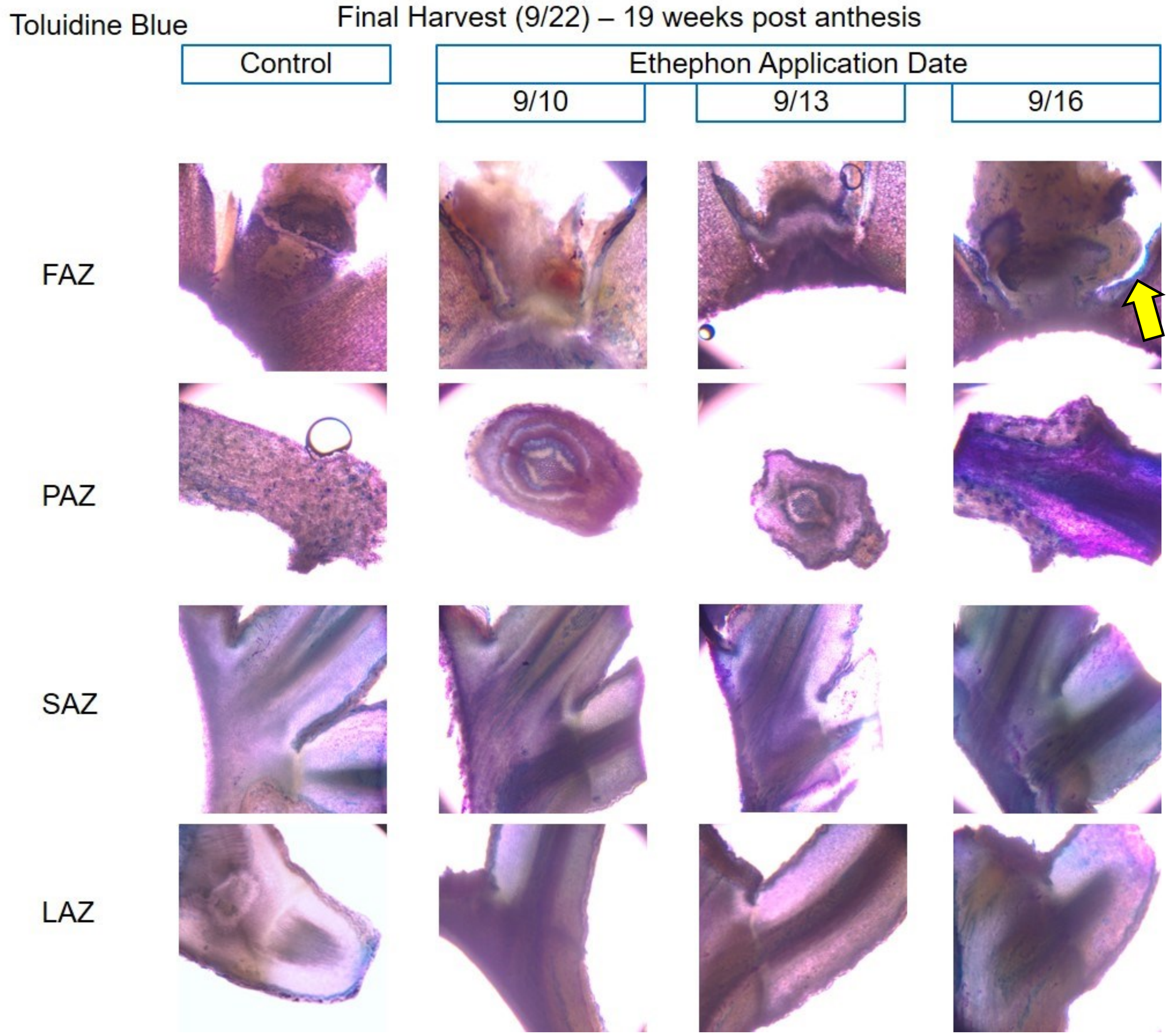


Figure 4. Toluidine blue staining of all potential abscission zones of untreated samples and by ethephon treated samples on different dates (19-week post-anthesis fruit branches, 25X, bright view). Yellow arrow indicates detachment of cell layers.

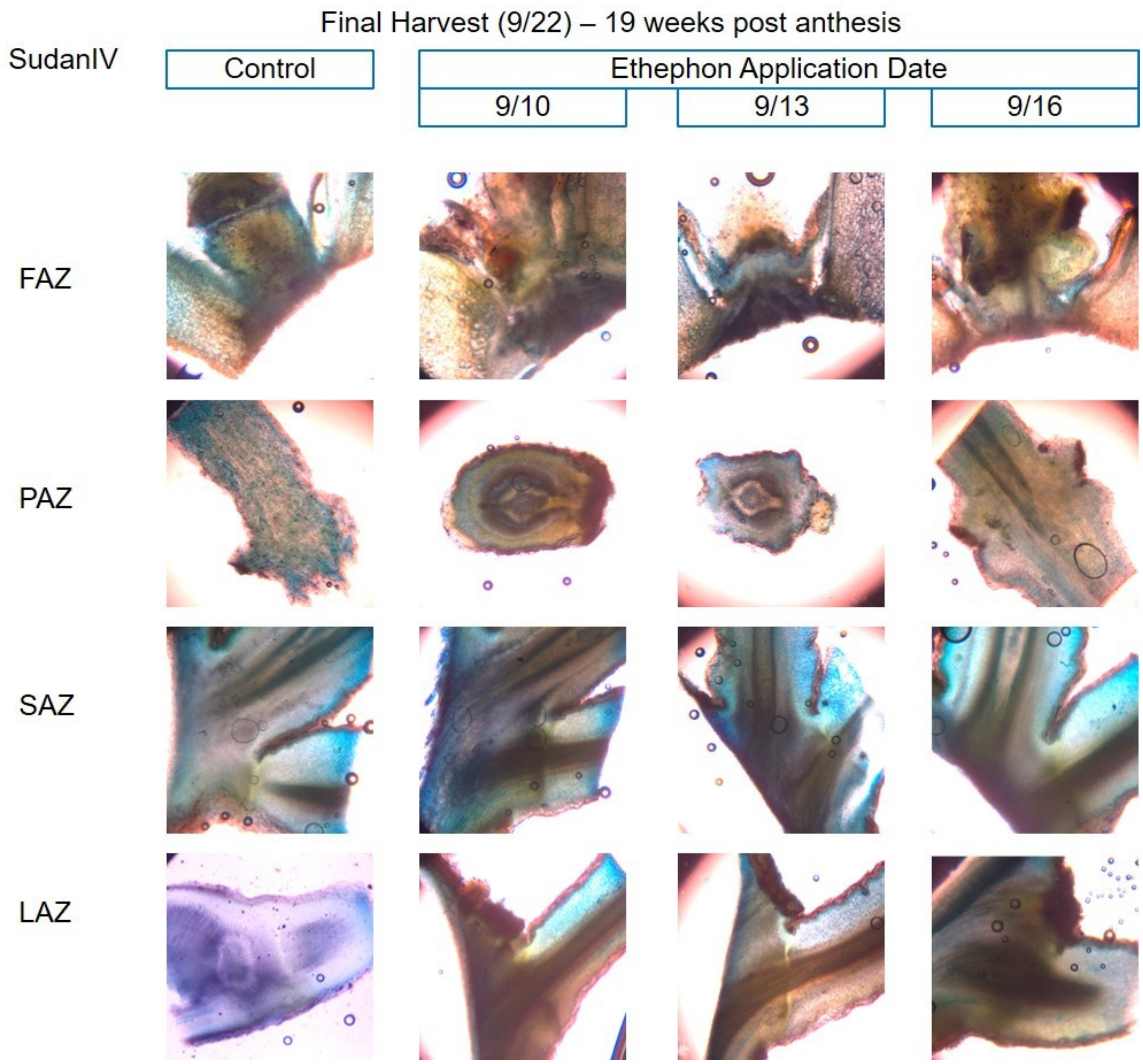


Figure 5. Sudan IV staining of all possible abscission sites of untreated samples and samples treated by ethephon on different dates (19-week post-anthesis fruit branches, 25X, bright view). The same samples were used in **Figures 4** and **5**, with **Figure 5** showing co-staining of toluidine blue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

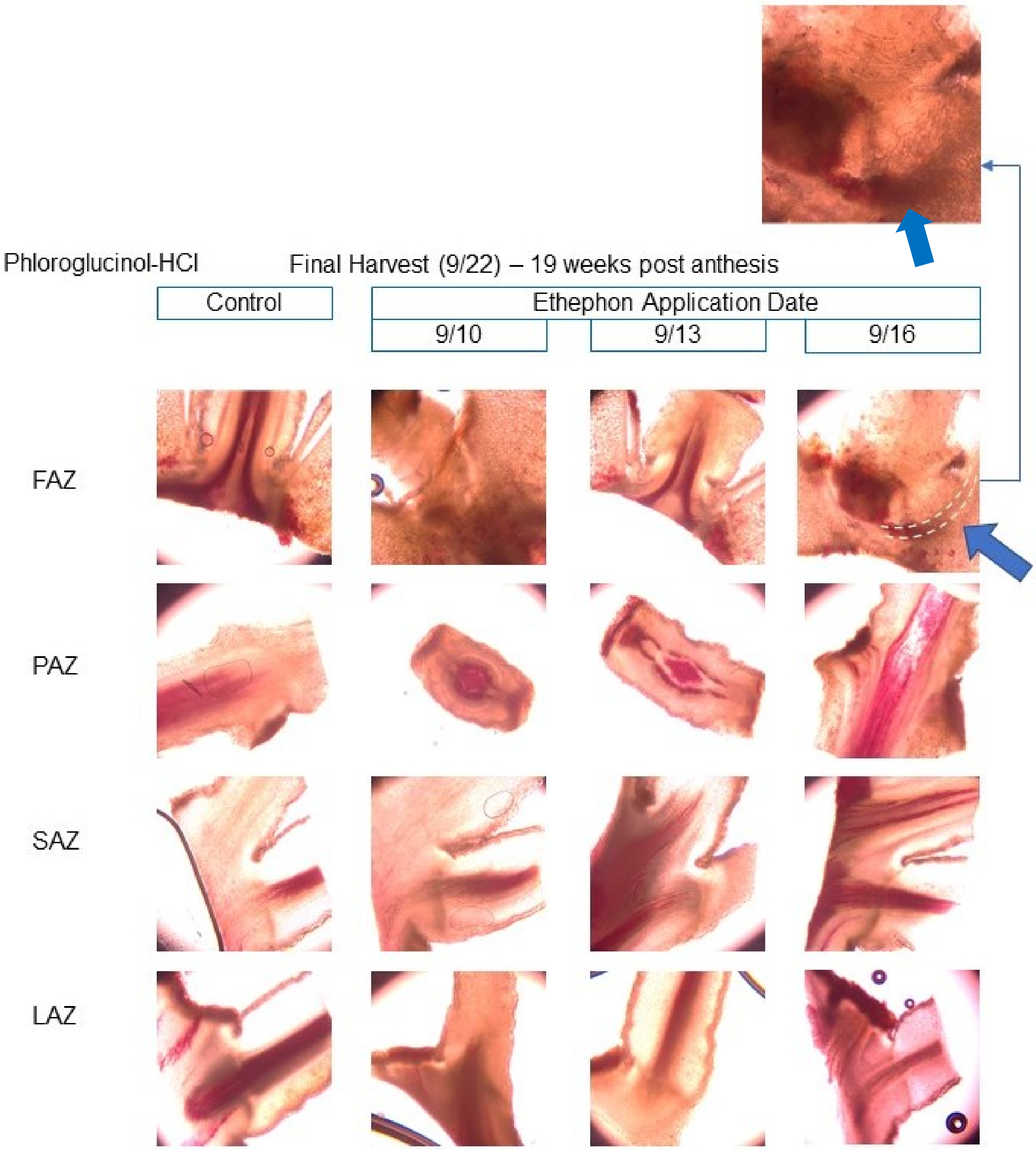


Figure 6. Phloroglucinol-HCl staining of all potential abscission zones of untreated samples and samples treated by ethephon on different dates. Lignified cells in FAZ are indicated by an arrow. (19-week post-anthesis fruit branches, 25X, bright view).

Anatomical analyses of FAZ suggested timely application of ethylene induces FAZ lignification

Based on our data described above (**Figure 6)**, ethephon application on 9/16 induces observable lignification in 9/22 final harvest samples. To verify these results, we analyzed 10 biological replicates of control group and ethephon treated samples from the 9/16 treatment. Indeed, ethephon treated groups showed 80% of FAZ with signs of lignification, versus only 30% observed in control group (**Figure 7**). Further we used Fuchsin (Kapp et al., 2015) to independently stain lignin at the FAZ. As shown in **Figure 8**, clear lignification at the FAZ confirms the polymer deposition. We also developed a protocol to quantify the level of lignification at FAZ by using Fuchsin staining. Altogether, our results confirmed that timely application of ethylene induces anatomical changes at FAZ as lignification of FAZ, and may be translated to lower fruit removal force and higher mechanical harvest efficiency.

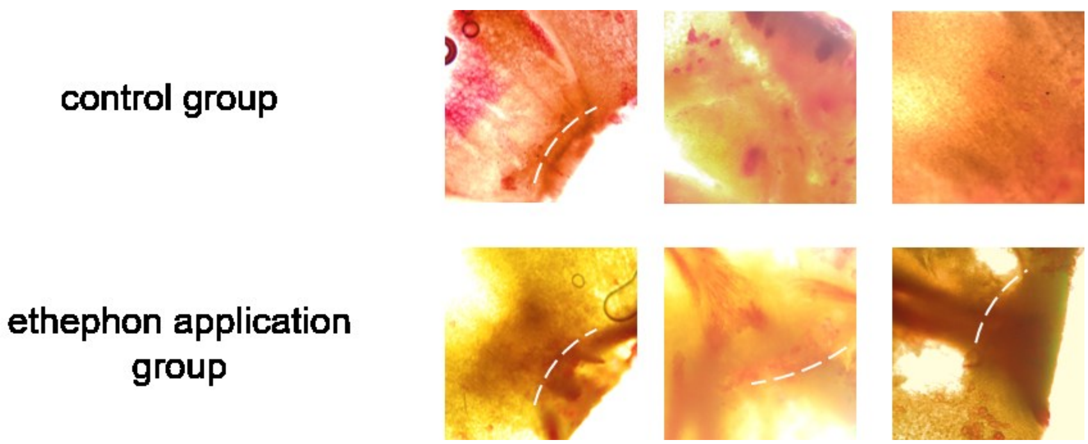


Figure 7. Higher rate of FAZ lignification is observed in ethephon treated group compared to the control group. Ten FAZ samples of 9/16 ethephon application group versus control group were stained by phloroglucinol-HCl. White dashed lines indicate observed lignification at FAZ as red stains of phloroglucinol-HCl. (25X, bright view)

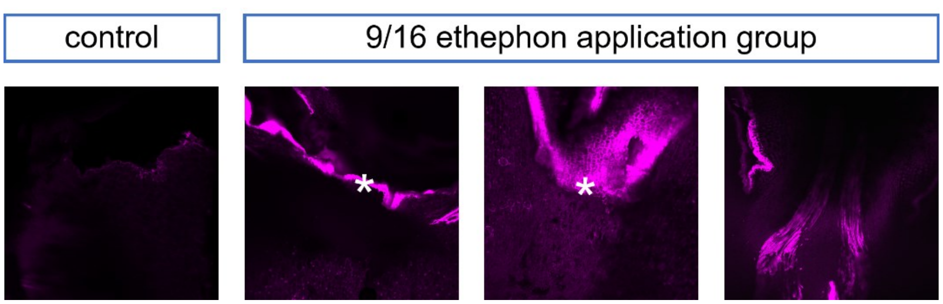


Figure 8. Fuchsin staining confirms the FAZ lignification in a quantifiable format. Two of three ethephon treated samples showed clear lignification at FAZ by Fuchsin staining, indicated by asterisks. A typical control sample does not have Fuchsin staining signal at FAZ. (20X, confocal microscope, 561 nm excitation and 593/40nm emission).

After-season leaf drop rate measurement

In after-season examination in April 2022, the Ferguson group reported that no major leaf drop was induced by the ethephon application versus control in 2021, in any ethephon application date group. These data eliminate the concern of the deteriorating effect of 1500 ppm ethephon application on the long-term tree health.

Summary

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. Our results so far indicate the induction of FAZ without the cost of major leaf drop. Overall, the study can 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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******ACTION REQUIRED******

FROM: RESEARCH SUBCOMMITTEE

SUBJECT: PRESENTATION OF COST STUDY

BACKGROUND:

Brittney Goodrich, Assistant Cooperative Extension Specialist, at UC Davis is here to present a proposal entitled, *Cost and Returns Studies for Table Olives.*

The most recent Table Olives Cost and Returns Study was conducted in 2016.

Researcher	Project	Amount
Brittney Goodrich	*Cost and Returns Studies for Table Olives*	**$13,359**

Proposal for Review by California Olive Committee
Title: Cost and Returns Studies for Table Olives in Sacramento Valley
PI: Brittney Goodrich, Assistant Cooperative Extension Specialist, UC Davis

Objective: The purpose of this proposed research is to update cost and returns studies for table olives in the Sacramento Valley. The most recent Table Olives Cost and Returns Study was conducted in 2016, and since then there have been significant changes in the cost of labor and other material inputs that are needed to produce table olives. These studies over time contribute to a deeper understanding of the industry and the major issues that it faces. In the long term this will help with better policy and regulatory frameworks and research.

Project timeline: July 1, 2022-June 30, 2023

Methods: Cost and return studies have been calculated and distributed by UC Davis Department of Agricultural and Resource Economics (ARE) for years. Members of the current Cost Study team (Jeremy Murdock, Donald Stewart, and Dr. Brittney Goodrich) have conducted hundreds of cost studies that are used throughout California and the world. The most important feature of these studies is that they are based on sound objective information from members of the industry and others with specific knowledge and expertise. Over 3,500 cost studies are maintained and are archived on the cost studies website (https://coststudies.ucdavis.edu/en/current/).

The table olive cost and return study will be completed within one year. The process begins with information gathering at a meeting with UCCE farm advisors, farmers and a research staff person from the Department of ARE. The narrative section of the study is compiled from the information gathered at the initial data collection meeting and is written in collaboration with the participating farm advisors. The studies report new information such as new technology in pest control. The new information is entered into the Budget Planer program which calculates costs and returns based on standardized economic and engineering formulas. From the initial meeting to publication of an updated study takes between four and six months, the timeline is dependent on the availability of the farmers and farm advisors.

Reporting: Findings for the table olive cost and returns study will be presented in a 20 to 25-page document detailing the expected costs and potential returns of producing the crop. This document will serve as a guide for table olive producers to make production decisions, estimate potential returns, prepare budgets and evaluate production loans. It will also provide useful information for farm lenders, land appraisers, government policy makers and other agricultural stakeholders in California. The study will be made available to the public electronically immediately upon completion via the UC Davis ARE Cost and Return Studies website https://coststudies.ucdavis.edu/en/current/ . The study release will be accompanied by a press release that facilitates broad dissemination in the farm media to assure that growers and others know that the studies are available.

Budget: The proposed cost of this project is $13,359. Requested funds will be used to compensate one of our cost and return study specialists who will be responsible for achieving the project objective of producing the sample cost and return studies.

Budget Justification
California Table Olive Committee
Title: Update Cost and Returns Study for Table Olives

Other Personnel: $7,923
Staff Research Associate will be responsible for achieving the project objective of producing the sample cost and return studies.
Salary is requested for 1.20 person months with an annual base salary of $76,922

Fringe Benefits: $4,112
Staff Research Associate benefit rate 51.9%

The benefits calculations are based on the University Federally approved Composite Benefit Rates based on each position and includes a 3% escalation. An explanation of the Composite Benefit Rates can be found: https://financeandbusiness.ucdavis.edu/finance/costing-policy-analysis/cbr

Total Direct Costs: $12,035

Indirect Costs: $1,324
Per sponsor correspondence Indirect Costs cannot exceed 11%.

Total Direct and Indirect costs: $13,359

****ACTION REQUIRED****

FROM: RESEARCH SUBCOMMITTEE

SUBJECT: DISCUSSION AND APPROVAL OF 2023 RESEARCH PRIORITIES

BACKGROUND:

- 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. Additionally, priorities are distributed to land grant universities across the nation and to private research facilities. Proposals will be reviewed for funding in November by the subcommittee.
- On the following page are the 2022 Research Priorities.

2022 RESEARCH PROJECTS FOR THE CALIFORNIA OLIVE COMMITTEE

Researcher	Project	Amount
Carol Lovatt Elizabeth Fitchtner	Managing Alternate Bearing in Olive with PGRs and Pruning	$29,217
Giulia Marino Louise Ferguson	Precise Water Management Strategies for Table Olive Orchards in California	$46,610
Reza Ehsani Louise Ferguson	Combining Limb Shaking and Canopy Shaking for Harvesting Mature Olive Trees	$34,902
J. E. Adaskaveg	Epidemiology and management of olive knot caused by Pseudomonas savastanoi pv.savastanoi	$11,150
J. E. Adaskaveg	Management of foliar diseases of olive (peacock spot)	$4,500
Georgia Drakakaki	Characterization of Olive Fruit Abscission Zone in Response to Timed Ethylene Applications and as a Function of Accumulated Heat Unit and Fruit Removal Force	$115,151
Jim Stewart	Southern San Joaquin Valley Olive Fruit Fly Monitoring Project	$11,000
Ernie Simpson	Sacramento Valley Olive Fruit Fly Monitoring Project	$9,250
	Contingency Fund	$ 35,000
	Total	**$296,780**

CALIFORNIA RIPE OLIVES
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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

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

FROM: RESEARCH SUBCOMMITTEE

SUBJECT: UPDATE ON CA SPECIALTY CROP BLOCK GRANT PROJECTS

BACKGROUND:

- The COC is currently carrying out one Specialty Crop Block Grant project entitled, *Preventing Xylella Fastidiosa in California Ripe Olives by Determining Susceptibility of California Ripe Olive Varieties*.

- The 2023 Specialty Crop Block Grant Program will be opening its application submission period in the Fall; as a result, the COC is currently looking for potential grant ideas from the Committee.
  - Funding Areas include:
    - Market Enhancement
    - Access, Education, and Training
    - Research

****INFORMATION ONLY****

FROM: RESEARCH SUBCOMMITTEE

SUBJECT: INTRODUCTION OF NEW OLIVE RESEARCHERS

BACKGROUND:

Elizabeth Fichtner is present to introduce a new team of researchers whose areas of research (ie. Irrigation/soil/plant physiology/engineering) will be able expand into table olives!