CALIFORNIA OLIVE COMMITTEE

PROJECT PLAN/2ND INTERIM REPORT

Workgroup/Department: Olive / Plant Sciences, UC Davis

Project Year October 16, 2014 Anticipated Duration of Project: 1 year: 7th of 7 years

Project Title: **Demonstrating Mechanical Pruning Can Produce Commercial Yields and Decrease Alternate Bearing**

Project Leaders:

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Cooperating Individuals:
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William Krueger MS: Glenn County Farm Advisor Emeritus: WHkrueger@UCNR.Edu

Cooperating Ranches:
Rocky Hill Ranch; Exeter California: Mark Pascoe; Pascoe32@MSN.com
Nickels Soils Laboratory; Arbuckle: Stan Cutter; CutterFarms@Frontier.net

Commodity: Olive Relevant AES/CE Project No.

Year Initiated: 2014 Current Funding Request: **24,087.00**

Progress Through October 16th, 2014

Thus far both orchards, Rocky Hill in Tulare County and Nickels Estate in Colusa County have been successfully pruned and both have been harvested. Due to a crop failure in Tulare County the Rocky Hill orchard was not mechanically harvested. The Colusa County orchard was successfully harvested. For both orchards the olives were submitted for grading by Musco Olive Company.

The data is still being analyzed. However, preliminary results demonstrate that mechanical pruning in both plots can significantly decrease canopy size while producing economic crops; 7.3 tons per acre for the hand pruned with mechanical pruning and 8.6 tons per acre for the mechanically pruned with a few hand cuts. Essentially the pruning work demonstrated hedgerows can be produced with hand or mechanical pruning, and produce economic crops. While both hedgerow orchards were harvested with equal efficiency, 88% for the hand pruned and 90% for the mechanically pruned, the latter were harvested with significantly less canopy damage than hedgerow canopies developed with hand pruning.

This project is now completed; a new proposal will be submitted to determine the best dimensions for mechanically pruned hedgerow orchards at this spacing in these latitudes.

The original proposal is given below.

<u>Problems and Significance:</u>
Developing mechanical harvesting is necessary if the California Black Ripe table olive industry is to survive, as manual harvest labor is increasingly expensive, unavailable and unskilled. The components necessary for successful table olive mechanical harvesting are a harvester that successfully removes olives and tree training and pruning that increase harvester efficiency. All the research thus far, including the most recent unpublished research from Israel, definitively demonstrates no effective abscission agents for decreasing olive fruit removal force have been identified.

We have successfully developed two harvest technologies, trunk shaking and canopy contact heads, that are now being further developed by commercial harvester fabricators. The training and pruning parameters that increase the fruit removal efficiency for trunk shakers were developed in the 50s and 60s. And as the two data sets given below demonstrate, we are now identifying the specific pruning and training methods that increase harvest efficiency for canopy contact harvester.

<u>Final Canopy Contact Harvester Efficiencies for Hedgerow Olive Orchards:</u>

A trial in 2013 demonstrated that the canopy contact mechanical harvesters can harvest topped and hedged trees in established orchards converted to moderate, 26 X 13 feet, 139 trees to the acre hedgerows with a 4.1 ton per acre crop with 92% efficiency versus 80% for unprepared trees with a 12.8 ton per acre crop at the same spacing.

A second trial in 2013 demonstrated that the canopy contact mechanical harvester can harvest topped and hedged hedgerow trees at a 12 X 18 spacing and a 4.2 ton/acre crop with 81% efficiency versus 79% efficiency for trees hand pruned to a hedgerow with a 3.7 ton per acre crop at the same spacing.

As the data above demonstrates we have achieved the needed 80% final harvest efficiency with the canopy contact harvester technology. University of California research on the canopy contact harvesters has now been completed and further development into a field ready harvester is being assumed by the commercial harvester industry. Dr. John Miles, Professor of Biological and Agricultural Engineering will release the final specifications for the canopy contact harvester head by January 2014.

As of October 2013 Coe Harvesting of Gridley, CA has committed to developing a commercial canopy contact harvester. Currently trunk shaking harvest efficiency remains below 70% in both commercial and private trials in California and Argentina. A technology other than, or in addition to, trunk shaking that better removes olives from heavily cropped table olive trees is needed. Preliminary trials have demonstrated the canopy contact harvesters alone, or in combination with trunk shaking can achieve this.

Because our trials have clearly demonstrated mechanical pruning of established orchards, 139 trees per acre, and developing moderate density hedgerow orchards, 202 trees per acre, increases both trunk shaking and canopy contact harvester efficiency we will continue to work with mechanical pruning of olive trees to demonstrate conclusively that mechanically pruning 'Manzanillo' hedgerow table olive orchards can:

1. **Produce commercial yields.**
2. **Decrease alternate bearing.**

BACKGROUND:

Effects of Mechanical Pruning on Olive Yields:

That mechanically pruned olives can produce commercial yields is clearly being demonstrated by the data given in Tables 1 and 2 below. In table 1 the 139 trees per acre mechanically pruned converted hedgerow orchard has averaged 4.2 tons per acre for 6 years. In table 2 the 202 trees per acre orchard developed as a hedgerow has maintained 4.1 tons per acre yield for three years. One more year of data for the first orchard and three more years of data from the second should demonstrate these orchards could reliably produce commercial yields with mechanical pruning.

These additional years of data collection are also needed to demonstrate that just as in pistachios, mechanical pruning can significantly decrease alternate bearing in olives. How is discussed below.

Effects of Mechanical Pruning on alternate Bearing of Olive:

Olives are among the fruit trees that bear crop on one-year old wood and simultaneously produce the shoot bearing next year's crop from the single vegetative bud on the tip of the one-year old wood. Olives are also apically dominant; growth from the shoot tip, not branching, produces virtually all new crop. This combination produces alternate bearing.

Pistachios, though deciduous, have the same growth and bearing habit as olives, and alternate bear even more regularly than olives. Mechanical pruning has been demonstrated to decrease alternate bearing in pistachios using the following mechanical pruning method. If mechanical topping and hedging is begun after the high crop year a high percentage of the flower buds that produce the coming low crop year are removed and the expected low crop is lower. In the same year there is a strong vegetative shoot growth that produces less flower buds than normally alternate bearing trees would. As a result the next year, the normal "on" year, the crop is again lower. Also, due to decreased crop, the shoots of these "on" year trees produce more flower buds. The next year, the normal "off" year these buds produce crop, and the expected low crop is higher. Thus, it requires two years of lowered crop for the alternate bearing to be initially mitigated. Once the alternate bearing swings have been decreased in amplitude regular mechanical pruning can maintain the decreased alternate bearing. This is the pattern that has been successfully implemented using mechanical pruning in pistachios.

The way mechanical pruning moderates alternate bearing without decreasing yields is by producing a better ratio of fruiting to non-fruiting shoots every year instead of allowing the majority of shoots on a tree to synchronize annually.

The data given in Tables 1 below demonstrates beginning mitigation of alternate bearing in an existing olive orchard and table 2 demonstrates it in a newly developed hedgerow orchard.

Table 1. 2007 – 2013:

Effect of Mechanical Topping and Hedging on Yield and Alternate Bearing

Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**Cumulative**	**Average Annual Yield**
Yield	**T/acre**	**T/acre**	**T/are**	**T/acre**	**T/acre**	**T/acre**	**T/acre**	**T/acre**
Harvest Method								
Mechanically Pruned	1.3	0.1	9.5b	7.9a	0.4c (H+T) 1.5b (H) 0.9 Average	4.1c (T) 6.4b 5.26 Average	23.3 26.7 25.0 Average	3.9 4.6 4.2 Average
Hand Pruned Control	1.5	0.2	12.4a	2.8b	2.3a	12.8a	32.0	5.3

Pruning Treatment	Hedge West: 6' Top: 12'	Hedge East: 6' Top: 12'	_______	Hedge West: 6'	Hedge East: 4' Top #3,5,7, 12'	Top #2,4,6 11.5'	**Difference +7.0 t/a Hand Pruned**	**Difference + 1.1 t/a Hand Pruned**
Significance	NSD	NSD	$P \leq 0.05$	$P \leq 0.05$	$P \leq 0.05$	$P \leq 0.05$		

Table 1. The table above demonstrates the effect of mechanical topping and hedging over a six-year period on annual yields, total cumulative yield and average annual yield. While the crop failures in 2008 and 2009, and partial crop failure in 2012, affected the data it can be clearly seen that the 2008 and 2009 pruning treatments increased yields in both 2010 and 2011. Additionally the mechanical pruning in 2011 increased yields in 2013. We predict, barring a fourth weather related crop failure the 2012 mechanical pruning treatments will increase yields in 2014 and there will be no significant differences in the average cumulative and annual yields per acre between the mechanically pruned and hand pruned trees, except that the mechanically pruned trees will have had much more marked annual swings in alternate bearing.

Table 2.
Effects of Hand Pruning vs. Mechanical Pruning on Yield: 2011 – 2013

Pruning Treatment	Yield	2011, 2012 and 2013 Cumulative Yield
	Tons/acre	Tons/Acre
Hand Pruned		
2011 Hand Pruned Hedgerow	0.8	
2012 Hand Pruned Hedgerow	5.1	
2013 Hand Pruned Hedgerow + Mechanically Hedged West 3' from trunk and 7* angle at top	5.1	

3 Year Average Annual Yield and Cumulative	**3.7**	**11.0**
Mechanically Pruned		
2011 Hedged East: 2‘ from Trunk Topped at 10’	0.4	
2012 Topped at 11’	6.7	
2013 Hedged West 3 from Trunk Two top hand cuts of highest branch	5.3	
3 Year Total	**4.1**	**12.4**

Table 2 above presents the effects of mechanical and hand pruning on yield and alternate bearing in a 12 X 18 hedgerow orchard established in 2001. Treatments were begun as described below each year. The data above demonstrates that thus far, through 3 years of 6, mechanical pruning does not decrease yield. Thus far it is too early to assess the effects of mechanical pruning on alternate bearing as at least three, two year cycles are required to see the effects of mechanical pruning on alternate bearing. However, we predict in 2014 the mechanically pruned trees will produce as well as the hand pruned trees with less alternate bearing, and at a lower cost for pruning.

HYPOTHESIS:
Mechanical topping and hedging can decrease alternate bearing of table olives without decreasing yield.

OBJECTIVES:
1.
Evaluate effects of mechanical pruning on yield, fruit quality and value, and alternate bearing in a 19 year old, 139 trees per acre orchard spaced at 13 X 26 feet.
II.
Evaluate effects of mechanical pruning on yield, fruit quality and value, and alternate bearing in a 12 year old, 202 trees per acre hedgerow orchard spaced at 12 X 18 feet.

Experimental Procedures:
Objectives 1: evaluating yield and alternate bearing in 139-trees/acre-hedgerow orchard.
Rocky Hill Ranch, Exeter, Tulare County: Manager, Mark Pascoe
Block 17 W:
19-year-old ‘Manzanillo’ orchard with ‘Sevillano’ pollinators (irregularly placed)
13, 83 tree, rows spaced at 13’ X 26’ (139 trees per acre)

<u>Experimental Design and Analysis:</u>
Split plot design with 6 replications of two treatments analyzed with SAS ANOVA.

<u>Pruning Treatments</u>: May-June 2014
Split plot with 6 hand-pruned and 6 mechanically pruned rows (replications)
Treatments: (late May to early June 2014 with Laux Pruning)

I. Mechanically top 3,5,7 of the 6 rows 11' from ground
II. Mechanically hedge all 6 rows on west side 4' from trunk
III. Mechanically skirt all trees 4 feet from the ground
    a. Remove large shoots bearing crop between trees.
    b. Remove branches between 180 and 90* degrees extending directly into the row.
IV. Hand prune control trees; 6 eastern rows.
V. Crop will be thinned with NAA.

<u>Data Collection</u>: September - October 2014.

1) Fruit removal force and individual fruit weight will be determined on 100 individual fruits/row.
2) All 13 rows will be individually hand harvested and bins per each row individually weighed
    a) Bins for each row will be delivered and reweighed at Musco Exeter receiving station.
    b) Bins for each row will receive a COC grade and adjusted value per ton at Musco receiving station.

<u>Fruit quality and value of olives will be based on:</u>
Yield per tree/or acre
Adjusted price per ton; based on fruit grading (size and quality)
Total canning percentage

<u>Experimental Procedures: Objective II.</u>
<u>Mechanical Pruning Trial with Canopy Contact Harvester: 202 trees per acre hedgerow.</u>
Nickels soils Laboratory, Arbuckle, Colusa County, California:
Manager: Stan Cutter
11 year-old 'Manzanillo' orchard with center Sevillano pollinator row
Olive Hedgerow Block: 13, 31 tree, rows of spaced at 12' X 18' (202 trees per acre)

<u>Experimental Design and Analysis:</u>
Randomized complete bock design with each treatment replicated once within 4, 3 row replications, split into 15 tree hand-pruned and mechanically pruned N/S halves.
Data analyzed with SAS ANOVA.

Treatments: (late May to early June 2014 with ENE Inc.),

I. Mechanically pruned treatments will be
    a. Hedge east side 2 feet from the trunk
    b. Topped as needed; to be determined after crop set
II. Skirt all trees 4' from ground.
    a. All large shoots bearing crop between trees will be removed.

    b. All branches between 180 and 90* degrees extending directly into the row will be removed.

III. Hand pruned control will simulate mechanical pruning but be done by hand.

IV. Trees will be thinned with NAA

<u>**Data Collection**</u>**: September - October 2014.**

3) Fruit removal force and individual fruit weight will be determined on 25 individual fruits/row within each pruning treatment.
4) All 12 rows will be individually hand harvested and bins per each row individually filed weighed within both pruning treatments.
    a) Bins for each row will be delivered and reweighed at Musco Orland receiving station.
    b) Bins for each row will receive a COC grade and adjusted value per ton at Musco receiving station.

<u>Fruit quality and value of olives will be based on:</u>

Yield per tree/or acre

Adjusted price per ton; based on fruit grading (size and quality)

Total canning percentage

<u>**Desired Results:**</u>

Demonstrate mechanical pruning can maintain yields while decreasing alternate bearing.

BUDGET REQUEST: 2012

BUDGET REQUEST – Part I

Budget Year: 2013-2014 Funding Source: COC

Salaries & Benefits:		
William H. Krueger: Glenn County Farm Advisor Emeritus		2, 500.00
Elizabeth J. Fichtner: Tulare County Farm Advisor		2,000.00
	Sub 1	**4,500.00**
Equipment Supplies & Expenses:		
Pruning and Harvesting Costs: (based on previous year's cost)		
Mechanical pruning and brush shredding at Rocky Hill (Laux Pruning)		2,500.00
Mechanical (ENE Inc.), and hand pruning, brush shredding: Nickels Estate		2,000.00
Miscellaneous harvest supplies: water, gloves, tarps, buckets		1,000.00
Total pruning and harvesting costs:		**5,500.00**
Sub 2		**10,000.00**
Experimental Travel Costs:		
Annual Truck lease and gas: 50% split with pistachio projects		**9,000.00**
Travel costs during Rocky Hill Harvests: 3 people @ 150/day and 6 days		**2,700.00**
Sub 3		**11,700.00**
Sub 4		**21,700.00**
UC Overhead @ 11%	**Sub 5**	**2,387.00**
TOTAL BUDGET		**24,087.00***

*** The budget for this project is dependent upon both Rocky Hill Ranch and Nickels Soils Laboratory paying hand harvest costs as they did in 2013.**

UNIVERSITY OF CALIFORNIA

	____________________ Originator's Signature	11/06/2011 Date
Agricultural Experiment Station	____________________ Department Chair	__________ Date
	____________________ Liaison Officer	__________ Date

Scope of Work

Dr. Louise Ferguson:
Responsible for overall coordination of the project, applying pruning treatments, executing harvest trials, data collection and analysis and writing final report.

Dr. Elizabeth Ficthner: Responsible for assisting with hand harvest at Rocky Hill Ranch in Tulare County.

William Krueger: Responsible for hand pruning treatment in Nickels trial and co-coordinator of harvesting trial in Colusa County.

External Contractors: contracts to be secured after funding.

Pruning Contract at Rocky Hill Ranch: Exeter, California
Gary Laux
Laux Management
1359 W Teapot Dome Avenue
Porterville, CA 93257-9378
Office: 559-781-0500 or 781-3116
Cell: 559-783-3212

Pruning Contract at Nickels Soils Laboratory: Colusa, California
Hillary Nielsen Porter
ENE Inc.
4453 County Road O
Orland CA 95963
ENE@EneInc.com
Office: 800-844-9409
FAX: 530-865-4845

Harvest Contractor at Rocky Hill Ranch: Tulare County
Antonio Villapando
Villapando AGI
Box 388
Woodlake, CA 93286
AVFarmLabor@yahoo.com
Office: 559-564-8071
FAX: 559-564-8050
Mobile: 559-805-3224

Department of Plant Pathology
Relevant AES/CE Project No.: 11103864

University of California
Division of Agricultural Sciences
INTERIM PROJECT/RESEARCH PROGRESS REPORT
July, 2014

Project Year: 2014

Project Leader:

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Title: Epidemiology and management of olive knot caused by *Pseudomonas savastanoi* pv. *savastanoi (Psv)*

2014 Research Objectives:

1) Epidemiology – pathogen variability, inoculum availability and period of susceptibility of selected injuries (leaf scars, pruning injuries, etc.) to infection
    a. Evaluate genetic pathogen variability using DNA markers
    b. Monitor galls for production of inoculum over time
    c. Duration of susceptibility of injuries under different environmental conditions (wetness and temperature)
2) Evaluate populations of the pathogen for laboratory sensitivity to chemicals
3) Test the performance of an equipment sanitizer (e.g., quaternary ammonium) under field conditions once registration has occurred.
4) Evaluate the efficacy of protective treatments such as new copper formulations, antibiotics (Kasumin, Mycoshield), captan, dodine, SAR compounds (acibenzolar-S-methyl - Actigard, PM-1, quinoxyfen, ProAlexin, Regalia), and combination treatments
    a. Field trials with and without adjuvants
    b. Timing studies: Protective (pre-infection) vs. post-infection activity of treatments; proper timing of SAR compounds; treatment at spring leaf drop or after harvest.
    c. Persistence of different copper treatments with and without the addition of lime or other additives under simulated rain conditions.
    d. Develop copper activity-enhancing materials such as mancozeb and other products

Summary of progress in 2014 including ongoing studies:

1a. Evaluation of *Psv* genetic variability of our current collection of strains using REP primers identified two main genotypes, comprising >95% of the 120 isolates from Northern California evaluated. Thus, variability was found to be very limited and additional genetic markers will be tested.

1b. In studies on inoculum production from galls over time, we showed that after wetting the galls, they can immediately produce inoculum at very high concentrations. Galls continued to produce inoculum with continued wetness duration. Thus, short wetness periods in the field can result in a high potential for new infections to occur.

1c. In fall 2013 field trials, we tested the susceptibility of injuries of cv. Manzanillo olives under different wetness conditions (overhead irrigation to simulate rain or no irrigation). Our results indicate that wounds were less susceptible to infection when provided with simulated rain as compared to no rain.

This result was unexpected. An explanation considered was that inoculum was washed off from the wounding sites by excess simulated rain. Injuries that received no irrigation remained susceptible to *Psv* even after 17 days (the maximum wound healing time tested). This is in contrast to our previous repeated studies on cv. Arbequina olives where inoculation of 10-day old injuries (leaf scar and lateral wounds) resulted in a very low incidence of knot formation. To determine if wound healing of cv. Manzanillo is different from cv. Arbequina, comparative studies will be done under controlled conditions in the greenhouse using both cultivars.

2. Laboratory studies were conducted on the in vitro activity of potential bactericidal treatments. We previously showed that systemic acquired resistance (SAR) compounds have no in vitro effect against *Psv*. Screening of the majority of our *Psv* collection (>100 strains) to the antibiotics oxytetracycline, streptomycin, and kasugamycin as well as different copper formulations has been accomplished. Strains showed a range of sensitivities to the three antibiotics but were all considered sensitive. Most strains in our collection showed reduced copper sensitivity in the 10- to 20-ppm range, however, one strain in our collection is considered copper-resistant with growth at 50 ppm MCE. Thus, copper resistance does occur in the pathogen population and its spread from overuse of copper products has to be minimized. This emphasizes the need for alternative treatments. In other vitro assays we tested several strains against new copper products (e.g., Magna Bon) and copper additives (thiadiazoles, dodine, etc.) with very promising results. These materials were evaluated due to EPA mandated registration restrictions of mancozeb (*see* 4d below).

3. In collaboration with the registrant, we submitted Deccosan 321, a quaternary ammonium compound, for a special local need registration for use in California, and approval is still pending. We are currently performing in vitro assays to compare the performance of Deccosan 321 to sodium hypochlorite using direct contact, as well as hard surface tests. Different concentrations and exposure durations are being compared for their effect on *Psv* viability. Results of direct contact tests indicated an exponential decrease in *Psv* viability with increased exposure duration to Deccosan 321 at very low rates (5 ppm) with an 84% reduction at 15 sec and a 97% reduction at 60 sec exposure. Deccosan at 25 ppm completely inactivated *Psv* after 15 sec. Thus, Deccosan 321 is a very effective sanitizer. Once a Section 24C is in place, we plan to test the material on harvesting and pruning equipment in the field.

4a. In the fall of 2013, field trials were done at UC Davis and in several commercial cv. Manzanillo and Arbequina olive groves. In evaluating these trials in spring 2014, we noted disease symptoms that we did not observe previously, even at study sites that were used in previous years. On cv. Manzanillo, and to a much lesser extent also on cv. Arbequina, many of the inoculations resulted in major shoot dieback and blistering on the inoculated as well as neighboring branches. Symptoms on non-inoculated neighboring branches are an indication of bacterial movement inside the host, and this was verified by bacterial isolation. We are currently conducting comparative greenhouse and field studies on both cultivars in an attempt to identify the cause of this dieback and systemic movement. Assays include using different inoculum concentrations, long periods of high humidity and wetness, and wrapping wounded and non-wounded olive branches with parafilm after inoculation. Observations made in past studies revealed that inoculated wounds that were parafilm-wrapped developed similar symptoms of a systemic infection. These studies will provide new information on the etiology of olive knot.

The severe disease development in Manzanillo and Arbequina experimental and commercial groves in the spring of 2013 compromised some of our bactericide efficacy studies. Severe dieback was observed on untreated, inoculated controls and on copper and copper-mixture treated trees in the commercial cv. Manzanillo orchard. Still, treatments with kasugamycin, streptomycin, and oxytetracycline significantly reduced dieback and had some control of systemic movement, caused by *Psv*. Kocide performed well at reducing the incidence of knots formed on lateral and leaf scar wounds when using a copper-sensitive strain for the inoculations and was moderately effective when using a copper-resistant strain. Kasugamycin gave moderate control when using a copper-sensitive strain and good control with a copper-resistant strain on lateral wounds, but leaf scar wounds were not well protected.

In a separate trial on cv. Arbequina olives, Kasumin, Kasumin-Syllit mixtures, and Kocide gave outstanding control of olive knot development on lateral wounds and moderate control on leaf scars. Streptomycin resulted in excellent control of *Psv* on lateral wounds but not on leaf scars. This trial also exhibited systemic infections but not on plants treated with Kasumin, Kasumin-Syllit, Kocide, or streptomycin. Syllit alone gave some control of *Psv* on lateral wounds but not on leaf scars but has great potential when used in mixtures with other treatments (i.e., Kasumin). In summary, although reduction in disease by bactericidal treatments was not as high as previously, treatments still significantly reduced the disease from the control. Higher inoculum levels were used in these studies as compared to previous years and this may have impacted symptom development and efficacy of treatments. Under these conditions, antibiotic treatments were able to significantly reduce dieback providing some measure of control against severe symptoms caused by *Psv* infection.

4b. Field trials in the fall of 2013 using SAR compounds (i.e., Regalia, ProAlexin, Stout, Actigard, and Quintec) resulted in little or no control of *Psv* when a foliar application was done 3 days before wound-inoculation. Again, branch dieback and systemic movement of the bacterium was observed on cv. Arbequina. In previous studies, significant reductions in disease were found using SARs (e.g., Regalia, quinoxyfen, Actigard, Stout). Thus, other timings of these treatments and application methods may be effective and will be considered in future trials.

4c. Field trials on cv. Manzanillo olives were performed in the fall of 2013 to test the persistence of treatments under simulated rain conditions at UC Davis. Treatments included Kasumin, Kocide 3000, Kocide with lime and zinc, and Kasumin with Kocide. There was severe systemic movement in all treatments with symptoms such as knots, bumps, and blistering occurring at and distant from the initial inoculation point. Therefore, these treatments did not persist and additional additives need to be tested. Trials are ongoing with products reported to increase the persistence of copper in other crops (carnauba-based adjuvants, Pinolene-based adjuvants).

4d. Evaluation of cv. Arbequina field trials at UC Riverside that were initiated in the spring of 2013 revealed that Kocide alone and in mixtures with Manzate performed similarly well as in previous studies against *Psv* on both leaf scar and lateral wounds. Badge X2 and a combination of different coppers were similarly effective, but Kasumin and Kasumin-Manzate mixtures did not perform well in this study but performed well in previous trials. Inoculum concentrations used were higher than previously and thus, limits to the antibiotic may occur under high disease pressure. In discussions with regulatory officials, EPA indicated that the Manzate label cannot be expanded to allow use on other crops. Kasugamycin is a pending IR-4 project once the pome fruit label is approved (e.g. for fire blight). In late spring of 2014 a field trial was initiated to test the efficacy of several copper formulations, as well as the antibiotics streptomycin, oxytetracycline, and kasugamycin. Kocide alone and in mixtures with several new promising copper activity-enhancing compounds are also being tested along with a novel compound (ceragenin) with a unique mode of action against bacteria. In field trials at UC Riverside we did not observe *Psv* systemic movement and severe dieback that we found in trials at UC Davis and in Sutter Co. on cv. Manzanillo and to a lesser extent on cv. Arbequina. Again, our planned studies on the etiology of disease establishment will help to explain differences in symptom expression which could provide useful insights for developing better management strategies.

CALIFORNIA OLIVE COMMITTEE

FINAL 2014 YEAR RESEARCH REPORT: ONGOING PROJECT
UPDATED 11/09/2014

Workgroup/Department: Olive / Plant Sciences, UC Davis

Project Year 2015 Anticipated Duration of Project: 3/10 year

Project Title:
Propagating Dwarfing Olive Rootstocks and Establishing a Long Term Orchard

Project Leaders:

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. John Preece, Curator, USDA National Clonal Germplasm Repository, Davis CA. John.Preece@usda.ars.gov
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Dr. Guiilana Marino, University of Palermo, Palermo, Italy: giulia.marino@unipa.it

Commodity: Olive Relevant AES/CE Project No.

Year Initiated: 2013 Current 2015 Funding Request: **13,245.00**

Problems and Significance:
To facilitate mechanical harvesting the newest table olive orchards are planted in hedgerows and are mechanically pruned to keep the trees small.

Hedgerow plantings and mechanical harvesting could be facilitated if Manzanillo scions could be grafted onto dwarfing rootstocks that kept them small.

The olives with slow growth and therefore potential for use dwarfing rootstocks are: Nikitskaya, *Olea cuspidate* Verticillium resistant Oblonga Seedling and Dwarf D.

We proposed to propagate these rootstocks, establish an orchard on the UC campus in coordination with the National Clonal Germplasm Repository and test them for their dwarfing potential with 'Manzanillo' to produce a tree that is more amenable to mechanical harvesting.

:

Progress through 11/07/2014:

This application for initial funding was for two purposes:

I. **Propagation and grafting of the rootstocks with 'Manzanillo' scions.**
   a. Dr. John Preece supervised the development of specific propagation techniques for 112 each of the following olive cultivars to be used as dwarfing rootstocks; Nikitskaya, *Olea cuspidate*, Verticillium Resistant Oblonga and Dwarf D. Dr. Pilar Rallo, partially supported by 2013 season funding, participated in this work.

II. **Established a 4-acre, split plot 'Manzanillo' table olive orchard in at the UC Davis Plant Sciences Field Facility.** The orchard was planted at 8 X 10 feet in the southern half and 10 X 15 feet in the northern half of the split plot block. The 13 tree sets of four different dwarfing rootstocks, and self grafted and ungrafted 'Manzanillos' planted at both tree spacings were replicated four times. Each block was surrounded by 'Sevillano' pollinizers; Attachment I: Field 3556 Plot Map

III. **Lacking and died in the field since planting: will be replaced in spring 2015.**
   a. 47 perimeter 'Sevillano' pollinizers, 45 not delivered and 2 died.
   b. 1 'Manzanillo' (died)
   c. 3 'Oblonga' (died)
   d. 5 'Nitskya' (died)
   e. 40 *O. cuspidate* (not propagated) and 2 (died)
   f. 63 'Dwarf D' (not propagated) and 9 (died)

Fig. 1. The four acre dwarfing rootstock trial on October4th, 2014, five months after planting on the north side of Hutchinson Road on the University of California Davis campus.

Objectives: 2015

I. **Propagate and plant missing 47 missing border row Sevillano pollinizers.**
II. **Establish a three-wire trellis and begin training.**

The UC staff will install the system: installation and includes materials and labor
The system will be installed between February and June 2015. The trellis system is designed to support a 16-foot anchored end post pole with metal stakes at each tree (already installed) and 3, 16-foot posts within the row (every 10 trees) Three permanent wires (11 gauge) will be secured to the end posts and attached to the metal tree stakes at 1, 2 and 3 m.

III. **Graft the Manzanillo scions to the rootstocks in winter/spring 2015.**
IV. **Begin initial growth measurements after grafting.**

UNIVERSITY OF CALIFORNIA

	Originator's Signature	11/06/2014 Date
Agricultural Experiment Station	Department Chair	Date
	Liaison Officer	Date

Scope of Work

Dr. Louise Ferguson:
Responsible for overall coordination of the project and directing orchard establishment in cooperation with UC Plant Sciences Field Crew. Collecting and analyzing data and writing up research reports.

Dr. John Preece:
Responsible for directing propagation of rootstocks, and being Co-PI for data collection, analysis and report writing.

James Jackson and Richard Pelzer:
Responsible for maintaining the orchard and field operations.

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

University of California
Division of Agricultural Sciences

PROJECT PLAN/RESEARCH GRANT PROPOSAL PROGRESS REPORT

Project Year: 2014 **Duration of Project: year 2 of 2**

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Title: Alternate Bearing in Olive - *Determining when fruit exert their negative effect on return bloom, whether the effect includes inhibition of floral development or only inhibition of bud break, and refining PGR treatments to break AB ON/OFF cycles*

Cooperator:
Lindcove REC Commercial table olive grove

Objective (1) - the fruit removal experiment was completed at spring bloom 2014. The results were striking:

(i) Only nonbearing shoots on the 2013 OFF-crop trees produce inflorescences at spring bloom 2104. For nonbearing shoots on the 2013 OFF-crop trees, 52%, 35% and 7% of buds at the first 8 node pairs, second 8 node pairs and basal 5 node pairs produced inflorescences in spring 2014, respectively, resulting in an ON bloom. Surprisingly, 43%, 50% and 59% of the buds along the shoot remained inactive, respectively (See Fig. 1).

(ii) In contrast, for bearing shoots on 2013 ON-crop trees, 75%, 76% and 71% of the floral buds had abscised from these shoot sections, respectively, 1 month before the 2014 bloom.

(iii) For nonbearing shoots on the 2013 ON-crop trees, 89% of the floral buds at the apical 8 node pairs, 67% for the floral buds of the middle 8 node pairs, and 63% of the floral buds at the basal 8 node pairs along the shoot remained inactive (dormant) at spring bloom 2014.

Research being conducted in 2014. We are determining the fate of all buds. Analysis of data from bearing shoots of OFF-crop trees reveals the local effect that fruit have on the fate of the buds with a limited effect from crop load because of the OFF-crop. The effect of crop load (the total number of fruit per tree) is determined by analyzing the fate of buds on nonbearing shoots (no local effect of fruit) on ON-crop trees versus the combined local and crop load effect of the fruit on the fate of the buds on bearing shoots on ON-crop trees. This is the first time we included bearing shoots on OFF-crop trees in our data collection and analyses. Starting in June this year, we have been determining whether buds actually form on bearing shoots of ON-crop trees and if so, when they abscise. Data collected June 10 2014 for the new spring shoot growth confirms the presence of buds at 92% of the node pairs (the youngest node pairs are in some cases too small to determine if buds are present on a given sampling date. There was no difference on the number of buds that formed per node between bearing and nonbearing shoots on ON- or OFF-crop trees; 98% of the buds were still present on September 13, 2014 (Table 1). However, new shoot growth at the apex of bearing shoots (shoots that set fruit basal to new growth in spring 2014) of OFF- and ON-crop trees had half the number of node pairs of nonbearing shoots on OFF- and ON-crop trees from June through September. Whereas shoot extension growth continued from June to September for nonbearing shoots on OFF- and ON-crop trees, bearing shoots on both OFF- and ON-crop trees basically stopped growing in June (Table 1). The new growth of bearing shoots on OFF- and ON-crop trees produced significantly fewer lateral vegetative shoots than nonbearing shoots on OFF- and ON-crop trees (Table 1). Lateral vegetative shoots may provide additional floral buds for next spring's bloom. We will confirm this at spring bloom 2015. This means that the individual fruit set on a bearing shoot have a greater negative effect on apical shoot extension growth and lateral shoot development than the total number of fruit per tree (crop load). There were no significant effects in response to the PGR treatments.

For the apical 8 nodes just behind the new growth, 17% of the buds had abscised on nonbearing shoots on OFF-crop trees and 8% on nonbearing shoots on ON-crop trees, but these differences were not significant. Significantly more buds had abscised on bearing shoots than nonbearing shoots by September. For bearing shoots of OFF-crop trees, 38% of buds had abscised versus 51% of buds on bearing shoots of ON-crop trees (Table 2). The latter result reflects the combined negative effect of fruit directly on a bearing shoot plus the effect of the entire ON-crop. For bearing shoots on OFF- or ON-crop trees, the number of abscised buds steadily increased from June through September (Table 2). Lateral vegetative shoot growth was significantly greater for nonbearing shoots than bearing shoots independent of the OFF- or ON-crop status of the trees. This section of the shoot set the greatest number of fruit (Table 2).

For the next (middle) 8 nodes of nonbearing shoots, 31% of the buds had abscised from OFF-crop trees, but significantly fewer (9%) had abscised from nonbearing shoots on ON-crop trees (Table 3). In contrast, for bearing shoots, 64% and 50% of the buds had abscised for OFF- and ON-crop trees, respectively. Nonbearing shoots on OFF- and ON-crop trees produced more lateral vegetative shoots than bearing shoots on OFF- and ON-crop trees (Table 3). The number of fruit set by this section of the mature shoot set was similar to that of the apical 8 nodes (Tables 2 and 3). There were no significant responses to the PGR treatments.

For the basal region of the mature shoot, there were less than 8 nodes (Table 4). For nonbearing shoots, 46% of the buds abscised for OFF-crop trees versus only 15% for ON-crop trees. For bearing shoots, 69% and 50% of buds had abscised on OFF- and ON-crop trees by September, respectively. There were no significant differences in the number of lateral vegetative shoots produced by nonbearing or bearing shoots on OFF- or ON-crop trees (Table 4). The basal part of the shoot set very few fruit (Table 4). There were no significant responses to the PGR treatments.

We are continuing to monitor the shoots to determine when additional floral bud abscission occurs. Floral bud abscission is an important new factor in understanding alternate bearing in olive. In pistachio, fruit-induced floral bud abscission has been known for over 40 years as the primary mechanism causing alternate bearing in pistachio; it does not occur in citrus or avocado. In pistachio foliar-application of a cytokinin plus urea in early June and again in early July increased floral bud retention by 2.5- to 3-fold. Thus far, we have not seen this response in olive.

Objective (2) - Nonbearing and bearing shoots on both ON- and OFF-crop trees have a high percentage of floral buds that remain inactive (dormant) through the spring bloom - determine whether these buds are viable floral buds that are inhibited from undergoing bud break (dormant) or nonviable floral buds due to inhibition of floral development by quantifying the expression of key genes regulating floral development.

Research being conducted in 2014. Our results thus far indicate that the developing ON crop of fruit does not inhibit the transition from vegetative growth to reproductive (floral) development (a process known as phase transition). However, inhibition of floral organ development was detected one month before full bloom. Two genes that function late in floral development were expressed in buds from nonbearing shoots of OFF-crop trees but not in buds from bearing or nonbearing shoots of ON-crop trees. Additional analyses will be done to confirm these results and clarify whether the buds are no longer viable floral buds or viable floral buds with delayed development.

Objective (3) - test the ability of PGRs applied to the canopy of ON-crop trees to increase vegetative shoot growth (number of nodes), reduce floral bud abscission per node, and increase bud break the next spring to increase floral intensity and yield the year following the ON-crop.
Research being conducted in 2014. The following PGR treatments were applied during the first week of June and again the first week of July (to increase shoot growth as node number, floral bud number and floral bud retention) and will be applied again in February (to increase spring bud break): (1) ON-crop control trees; (2) ON-crop trees treated with 6-BA + low-biuret urea; (3) ON-crop trees treated with cytokinin X (a natural product) + low-buiret urea; (4) OFF-crop trees treated with cytokinin X; and (5) OFF-crop control trees. The PGRs were applied at 0.9 g/tree, low-biuret urea at 0.18 kg N per tree. In our previous proof-of-concept research in two different orchards, 6-BA and cytokinin X were as effective when used alone as when they were combined with an auxin-transport inhibitor in significantly increasing the number of inflorescences produced by nonbearing shoots on ON-crop trees the following spring; the increase in flowering by bearing shoots on ON-crop trees was increased but not significantly. We are testing the cytokinins with low-biuret urea for three reasons: (1) to supply N to support PGR-stimulated shoot growth; (2) 6-BA plus urea increases floral bud retention 2.5- to 3-fold during the ON-crop year of pistachio and increases yield to the same degree (this use is on the Valent BioSciences 6-BA label; if successful, it should be easy to add olive to the label); and (3) to increase the potential for either cyokinin to be available to olive growers sooner, we used them alone without the complication of a second hormone, the auxin-transport inhibitor.

The take home message: By September 13, 2014, new growth on bearing shoots of OFF- and ON-crop trees had 50% fewer nodes to bear potential floral buds for next spring's bloom than nonbearing shoots on OFF- or ON-crop trees. Shoot extension growth of bearing shoots on OF- and ON-crop trees stopped in June. For the new growth on nonbearing and bearing shoots on OFF- or ON-crop trees, 90% of the nodes developed buds and 98% of those buds were still on the tree through September 13, 2014. For the 8-node sections of mature bearing shoots on OFF- and ON-crop trees, significant percentages (38% to 69%) of the buds abscised by September. Interestingly, approximately 30% of the buds on nonbearing shoots on OFF- and ON-crop trees produced lateral vegetative shoots by September. At spring bloom we will determine whether these lateral vegetative shoots contribute inflorescences to bloom to the 2015 spring bloom. Floral induction, which occurs in the summer, does not appear to be inhibited since key floral genes that promote flowering are expressed equally in the buds of nonbearing shoots of OFF-crop trees and bearing shoots of ON-crop trees. However, the final stages of floral organ development are inhibited in buds on bearing and nonbearing shoots of ON-crop trees. Thus, the negative effect of fruit on floral development and floral bud abscission is both a local effect on bearing shoots and a crop load effect on both nonbearing and bearing shoots on ON-crop trees. Thus far, there have been no significant responses to the PGR treatments applied this June and July on vegetative shoot extension growth, lateral vegetative shoot growth, or in reducing bud abscission. Potential benefits of the PGR treatments to increase spring bud break or overcome fruit-induced inhibition of the late stages of floral development will be determined at spring bloom.

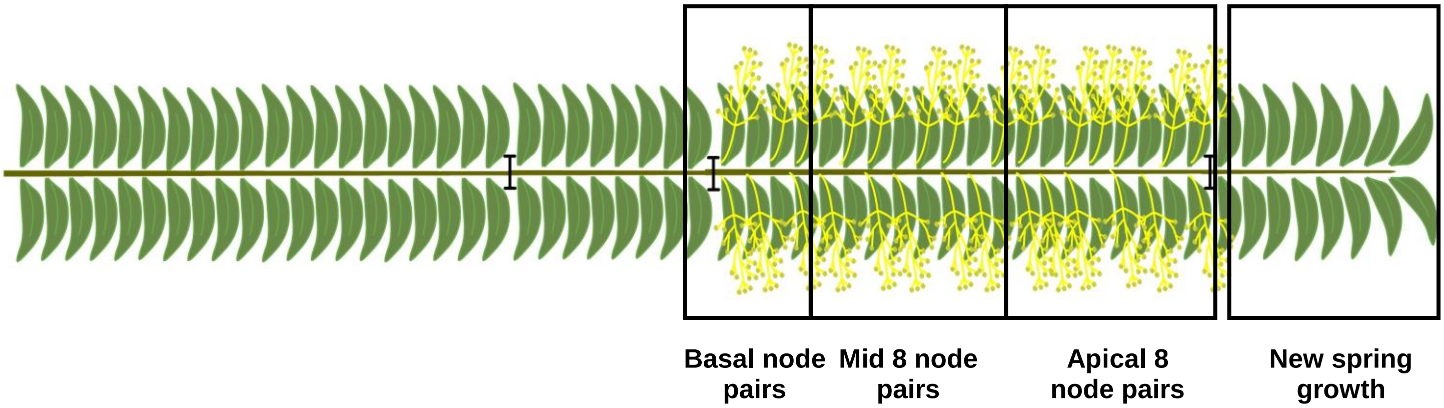

Fig. 1. Model of a bearing shoot of an ON-crop 'Manzanillo' olive tree in spring, showing where inflorescences are produced and fruit set per node pairs spanning the new growth, and apical, mid and basal nodes pairs of the mature shoot. The fate of every bud, i.e., whether the bud remained inactive (dormant), abscised, or produced a vegetative shoot or set fruit, was determined for the new spring shoot growth and previous year's shoot growth (24 node pairs) monthly from June through September. We will continue to determine the fate of the buds through spring bloom.

Table 1. Effect of crop load and foliar applied cytokinins +/- urea on the fate of buds on new apical vegetative shoot growth of ‘Manzanillo’ olive trees in Exeter, CA.

Treatment	Status	June	July	August	September	*P*-value
		Number of Node Pairs				
Nonbearing shoots						
Control	Off	5.8 a^{Bz}	6.3 a^{A}	6.6 a^{A}	6.7 a^{A}	0.0003
Adenosine	Off	5.5 a^{C}	6.1 a^{B}	6.5 a^{A}	6.6 a^{A}	<0.0001
Control	On	6.5 a^{C}	6.8 a^{B}	7.1 a^{A}	7.2 a^{A}	<0.0001
Adenosine + Urea	On	6.3 a^{BC}	6.2 a^{C}	6.6 a^{AB}	6.7 a^{A}	0.0196
6-BA + Urea	On	5.9 a^{C}	6.4 a^{B}	7.0 a^{A}	6.9 a^{A}	<0.0001
Bearing Shoots						
Control	Off	3.0 b^{A}	3.2 b^{A}	3.1 b^{A}	3.1 b^{A}	0.4922
Adenosine	Off	2.8 b^{A}	2.8 b^{A}	2.7 b^{A}	2.8 b^{A}	0.7312
Control	On	2.4 b^{A}	2.4 b^{A}	2.4 b^{A}	2.3 b^{A}	0.9821
Adenosine + Urea	On	2.6 b^{A}	2.5 b^{A}	2.4 b^{A}	2.5 b^{A}	0.8686
6-BA + Urea	On	3.3 b^{A}	3.1 b^{A}	3.3 b^{A}	3.2 b^{A}	0.4122
P-value		<0.0001	<0.0001	<0.0001	<0.0001	
		Number of Lateral Vegetative Shoots				
Nonbearing shoots						
Control	Off	0.5 ab^{A}	1.7 ab^{A}	1.2 bc^{A}	1.0 bcd^{A}	0.1073
Adenosine	Off	0.0 b^{A}	1.1 bc^{A}	0.8 cd^{A}	1.3 bc^{A}	0.1271
Control	On	1.0 a^{B}	2.3 a^{AB}	2.7 a^{A}	3.0 a^{A}	0.0414
Adenosine + Urea	On	0.1 b^{B}	1.7 ab^{A}	2.1 ab^{A}	1.8 b^{A}	0.0087
6-BA + Urea	On	0.3 b^{B}	1.9 ab^{A}	2.2 a^{A}	1.6 b^{A}	0.0068
Bearing Shoots						
Control	Off	0.0 b^{B}	0.2 c^{A}	0.0 d^{AB}	0.0 d^{AB}	0.1005
Adenosine	Off	0.0 b^{A}	0.3 c^{A}	0.1 d^{A}	0.0 d^{A}	0.1632
Control	On	0.0 b^{A}	0.1 c^{A}	0.2 d^{A}	0.0 d^{A}	0.2912
Adenosine + Urea	On	0.0 b^{A}	0.2 c^{A}	0.1 d^{A}	0.2 cd^{A}	0.1592
6-BA + Urea	On	0.2 b^{A}	0.6 c^{A}	0.2 d^{A}	0.1 d^{A}	0.1512
P-value		0.0029	<0.0001	<0.0001	<0.0001	
		Number of Buds that Abscised				
Nonbearing shoots						
Control	Off	0.1 bcd^{A}	0.1 a^{A}	0.1 a^{A}	0.2 ab^{A}	0.3629
Adenosine	Off	0.0 d^{A}	0.3 a^{A}	0.0 a^{A}	0.0 b^{A}	0.1353
Control	On	0.0 d^{A}	0.7 a^{A}	0.1 a^{A}	0.0 b^{A}	0.1497
Adenosine + Urea	On	0.1 bcd^{A}	0.2 a^{A}	0.2 a^{A}	0.2 ab^{A}	0.6604
6-BA + Urea	On	0.0 d^{A}	0.1 a^{A}	0.0 a^{A}	0.0 b^{A}	0.5337
Bearing Shoots						
Control	Off	0.0 cd^{A}	0.0 a^{A}	0.1 a^{A}	0.0 b^{A}	0.3066
Adenosine	Off	0.0 d^{B}	0.1 a^{A}	0.0 a^{B}	0.1 b^{AB}	0.0663
Control	On	0.4 ab^{A}	0.2 a^{A}	0.2 a^{A}	0.1 ab^{A}	0.2253
Adenosine + Urea	On	0.3 abc	0.3 a^{A}	0.2 a^{A}	0.3 a^{A}	0.7005
6-BA + Urea	On	0.5 a^{A}	0.2 a^{A}	0.4 a^{A}	0.3 a^{A}	0.2587
P-value		0.0024	0.4444	0.1613	0.0343	

		Number of Inactive Buds				
Nonbearing shoots						
Control	Off	10.7 a^{C}	10.8 a^{BC}	12.0 a^{AB}	12.3 a^{A}	0.0168
Adenosine	Off	11.0 a^{AB}	10.7 a^{B}	12.2 a^{A}	12.0 a^{A}	0.0661
Control	On	11.9 a^{A}	10.6 a^{A}	11.4 a^{A}	11.4 a^{A}	0.3369
Adenosine + Urea	On	12.4 a^{A}	10.5 a^{B}	10.9 a^{B}	11.5 a^{AB}	0.0565
6-BA + Urea	On	11.5 a^{AB}	10.7 a^{B}	11.7 a^{AB}	12.2 a^{A}	0.0449
Bearing Shoots						
Control	Off	5.9 b^{A}	6.3 b^{A}	6.1 b^{A}	6.2 b^{A}	0.6397
Adenosine	Off	5.7 b^{A}	5.2 bc^{A}	5.3 b^{A}	5.6 b^{A}	0.3078
Control	On	4.4 b^{A}	4.4 c^{A}	4.3 b^{A}	4.5 b^{A}	0.8844
Adenosine + Urea	On	4.8 b^{A}	4.6 bc^{A}	4.6 b^{A}	4.5 b^{A}	0.7383
6-BA + Urea	On	5.9 b^{A}	5.5 bc^{A}	6.1 b^{A}	6.1 b^{A}	0.1328
P-value		<0.0001	<0.0001	<0.0001	<0.0001	
		Number of Nodes Bearing Fruit				
Nonbearing shoots						
Control	Off	0.0 b^{A}	0.0 a^{A}	0.0 a^{A}	0.0 a^{A}	.
Adenosine	Off	0.0 b^{A}	0.0 a^{A}	0.0 a^{A}	0.0 a^{A}	.
Control	On	0.0 b^{A}	0.0 a^{A}	0.0 a^{A}	0.0 a^{A}	.
Adenosine + Urea	On	0.0 b^{A}	0.0 a^{A}	0.0 a^{A}	0.0 a^{A}	.
6-BA + Urea	On	0.0 b^{A}	0.0 a^{A}	0.0 a^{A}	0.0 a^{A}	.
Bearing Shoots						
Control	Off	0.0 b^{A}	0.0 a^{A}	0.0 a^{A}	0.0 a^{A}	0.4023
Adenosine	Off	0.0 b^{A}	0.0 a^{A}	0.1 a^{A}	0.0 a^{A}	0.1428
Control	On	0.1 a^{A}	0.0 a^{A}	0.1 a^{A}	0.0 a^{A}	0.5708
Adenosine + Urea	On	0.0 ab^{A}	0.0 a^{A}	0.0 a^{A}	0.0 a^{A}	0.5867
6-BA + Urea	On	0.0 ab^{A}	0.0 a^{A}	0.0 a^{A}	0.0 a^{A}	.
P-value		0.5111	0.4436	0.3706	0.4045	
		Number of Fruit				
Nonbearing shoots						
Control	Off	.	.	0.0 a^{A}	0.0 a^{A}	.
Adenosine	Off	.	.	0.0 a^{A}	0.0 a^{A}	.
Control	On	.	.	0.0 a^{A}	0.0 a^{A}	.
Adenosine + Urea	On	.	.	0.0 a^{A}	0.0 a^{A}	.
6-BA + Urea	On	.	.	0.0 a^{A}	0.0 a^{A}	.
Bearing Shoots						
Control	Off	.	.	0.0 a^{A}	0.0 a^{A}	0.3343
Adenosine	Off	.	.	0.1 a^{A}	0.1 a^{A}	0.3343
Control	On	.	.	0.1 a^{A}	0.0 a^{A}	0.3343
Adenosine + Urea	On	.	.	0.0 a^{A}	0.0 a^{A}	0.3343
6-BA + Urea	On	.	.	0.0 a^{A}	0.0 a^{A}	.
P-value		.	.	0.3652	0.4089	

^{z} Values in a vertical column followed by different lower case letters or in a horizontal row followed by different uppercase superscript letters are significantly different at the *P*-value specified by Fisher's Protected LSD Test.

Table 2. Effect of crop load and foliar applied cytokinins +/- urea on the fate of buds on the apical 8 node pairs along a mature shoot of ‘Manzanillo’ olive trees in Exeter, CA.

Treatment	Status	June	July	August	September	*P*-value
		Number of Node Pairs				
Nonbearing shoots						
Control	Off	8.0 a^{Az}	8.0 a^{A}	8.0 a^{A}	8.0 a^{A}	.
Adenosine	Off	8.0 a^{A}	8.0 a^{A}	8.0 a^{A}	8.0 a^{A}	.
Control	On	8.0 a^{A}	8.0 a^{A}	8.0 a^{A}	8.0 a^{A}	.
Adenosine + Urea	On	8.0 a^{A}	8.0 a^{A}	8.0 a^{A}	8.0 a^{A}	.
6-BA + Urea	On	8.0 a^{A}	8.0 a^{A}	8.0 a^{A}	8.0 a^{A}	.
Bearing Shoots						
Control	Off	8.0 a^{A}	8.0 a^{A}	8.0 a^{A}	8.0 a^{A}	.
Adenosine	Off	8.0 a^{A}	8.0 a^{A}	8.0 a^{A}	8.0 a^{A}	.
Control	On	8.0 a^{A}	8.0 a^{A}	8.0 a^{A}	8.0 a^{A}	.
Adenosine + Urea	On	8.0 a^{A}	8.0 a^{A}	8.0 a^{A}	8.0 a^{A}	.
6-BA + Urea	On	8.0 a^{A}	8.0 a^{A}	8.0 a^{A}	8.0 a^{A}	.
P-value		.	.	.	.	
		Number of Lateral Vegetative Shoots				
Nonbearing shoots						
Control	Off	1.4 a^{C}	4.2 abc^{A}	4.2 ab^{A}	2.9 b^{B}	0.0001
Adenosine	Off	1.3 a^{B}	3.1 bcd^{A}	2.8 bc^{A}	2.9 b^{A}	0.0029
Control	On	1.3 a^{B}	5.8 a^{A}	5.3 a^{A}	5.5 a^{A}	0.0001
Adenosine + Urea	On	1.1 ab^{B}	4.3 ab^{A}	4.7 a^{A}	5.1 a^{A}	0.0004
6-BA + Urea	On	0.7 abc^{B}	4.8 a^{A}	5.1 a^{A}	4.2 ab^{A}	<0.0001
Bearing Shoots						
Control	Off	1.2 ab^{B}	2.6 cde^{A}	2.4 cd^{A}	1.3 c^{B}	0.0008
Adenosine	Off	1.2 a^{B}	2.5 de^{A}	2.2 cde^{AB}	1.2 c^{B}	0.0448
Control	On	0.5 bc^{B}	2.2 de^{A}	1.1 de^{B}	1.0 c^{B}	0.0002
Adenosine + Urea	On	0.9 abc^{A}	1.4 e^{A}	1.0 e^{A}	1.0 c^{A}	0.5450
6-BA + Urea	On	0.3 c^{C}	1.3 e^{A}	1.0 e^{AB}	0.6 c^{BC}	0.0079
P-value		0.0349	<0.0001	<0.0001	<0.0001	
		Number of Buds that Abscised				
Nonbearing shoots						
Control	Off	2.1 bcd^{A}	2.1 d^{A}	2.9 cd^{A}	2.7 cd^{A}	0.2464
Adenosine	Off	2.6 bcd^{B}	3.9 bc^{A}	4.0 bc^{A}	4.5 bc^{A}	0.0004
Control	On	1.2 d^{A}	0.9 d^{A}	1.2 d^{A}	1.2 d^{A}	0.5969
Adenosine + Urea	On	1.8 cd^{A}	2.0 d^{A}	2.0 d^{A}	2.1 d^{A}	0.4483
6-BA + Urea	On	2.0 bcd^{A}	2.4 cd^{A}	2.3 cd^{A}	2.6 d^{A}	0.3497
Bearing Shoots						
Control	Off	3.1 bc^{C}	4.2 b^{B}	5.3 b^{A}	6.1 b^{A}	<0.0001
Adenosine	Off	3.5 b^{C}	4.0 bc^{BC}	4.8 b^{AB}	5.4 b^{A}	0.0029
Control	On	7.3 a^{B}	7.6 a^{B}	8.8 a^{A}	8.1 a^{AB}	0.0280
Adenosine + Urea	On	8.2 a^{B}	8.2 a^{B}	8.5 a^{B}	9.6 a^{A}	0.0019
6-BA + Urea	On	7.5 a^{C}	8.3 a^{B}	9.2 a^{A}	9.3 a^{A}	<0.0001
P-value		<0.0001	<0.0001	<0.0001	<0.0001	

		Number of Inactive Buds				
Nonbearing shoots						
Control	Off	12.5 a^{A}	9.6 a^{B}	8.9 a^{B}	10.4 a^{B}	0.0006
Adenosine	Off	12.2 a^{A}	9.1 ab^{B}	9.3 a^{B}	8.7 ab^{B}	<0.0001
Control	On	13.5 a^{A}	9.3 a^{B}	9.5 a^{B}	9.3 a^{B}	0.0011
Adenosine + Urea	On	13.2 a^{A}	9.7 a^{B}	9.3 a^{B}	8.9 ab^{B}	0.0001
6-BA + Urea	On	13.3 a^{A}	8.8 abc^{B}	8.6 a^{B}	9.3 a^{B}	<0.0001
Bearing Shoots						
Control	Off	9.3 b^{A}	6.6 c^{B}	5.2 bc^{C}	5.7 cd^{BC}	<0.0001
Adenosine	Off	9.0 b^{A}	7.0 bc^{B}	6.4 b^{B}	6.9 bc^{B}	0.0081
Control	On	6.0 c^{A}	3.5 d^{B}	3.3 d^{B}	4.0 de^{B}	0.0002
Adenosine + Urea	On	5.0 c^{A}	3.8 d^{B}	3.9 cd^{B}	2.6 e^{C}	0.0017
6-BA + Urea	On	6.2 c^{A}	4.3 d^{B}	3.4 d^{B}	3.7 de^{B}	<0.0001
P-value		<0.0001	<0.0001	<0.0001	<0.0001	
		Number of Nodes Bearing Fruit				
Nonbearing shoots						
Control	Off	0.0 c^{A}	0.0 c^{A}	0.0 c^{A}	0.0 c^{A}	.
Adenosine	Off	0.0 c^{A}	0.0 c^{A}	0.0 c^{A}	0.0 c^{A}	.
Control	On	0.0 c^{A}	0.0 c^{A}	0.0 c^{A}	0.0 c^{A}	.
Adenosine + Urea	On	0.0 c^{A}	0.0 c^{A}	0.0 c^{A}	0.0 c^{A}	.
6-BA + Urea	On	0.0 c^{A}	0.0 c^{A}	0.0 c^{A}	0.0 c^{A}	.
Bearing Shoots						
Control	Off	2.4 a^{C}	2.6 a^{BC}	3.1 a^{A}	3.0 a^{AB}	0.0040
Adenosine	Off	2.4 ab^{A}	2.5 ab^{A}	2.7 ab^{A}	2.5 ab^{A}	0.3240
Control	On	2.1 ab^{B}	2.8 a^{A}	2.8 ab^{A}	2.9 a^{A}	0.0012
Adenosine + Urea	On	1.9 b^{B}	2.7 a^{A}	2.7 ab^{A}	2.7 ab^{A}	<0.0001
6-BA + Urea	On	2.0 ab^{B}	2.1 b^{AB}	2.5 b^{A}	2.4 b^{AB}	0.0708
P-value		<0.0001	<0.0001	<0.0001	<0.0001	
		Number of Fruit				
Nonbearing shoots						
Control	Off	.	.	0.0 d^{A}	0.0 d^{A}	.
Adenosine	Off	.	.	0.0 d^{A}	0.0 d^{A}	.
Control	On	.	.	0.0 d^{A}	0.0 d^{A}	.
Adenosine + Urea	On	.	.	0.0 d^{A}	0.0 d^{A}	.
6-BA + Urea	On	.	.	0.0 d^{A}	0.0 d^{A}	.
Bearing Shoots						
Control	Off	.	.	6.6 a^{A}	5.9 a^{B}	0.0190
Adenosine	Off	.	.	5.1 b^{A}	4.8 b^{B}	0.0395
Control	On	.	.	4.2 bc^{A}	4.2 bc^{A}	0.8916
Adenosine + Urea	On	.	.	3.6 c^{A}	3.5 c^{A}	0.4390
6-BA + Urea	On	.	.	3.3 c^{A}	3.3 c^{A}	0.8618
P-value		.	.	<0.0001	<0.0001	

[z] Values in a vertical column followed by different lower case letters or in a horizontal row followed by different uppercase superscript letters are significantly different at the *P*-value specified by Fisher's Protected LSD Test.

Table 3. Effect of crop load and foliar applied cytokinins +/- urea on the fate of buds on the middle 8 node pairs along a mature vegetative shoot of 'Manzanillo' olive trees in Exeter, CA.

Treatment	Status	June	July	August	September	*P*-value
		Number of Node Pairs				
Nonbearing shoots						
Control	Off	7.9 ab^{Az}	7.9 a^{A}	7.8 a^{A}	7.9 abc^{A}	0.2877
Adenosine	Off	8.0 a^{A}	7.9 a^{A}	7.9 a^{A}	7.9 ab^{A}	0.6894
Control	On	7.8 ab^{A}	7.9 a^{A}	7.8 a^{A}	7.8 abc^{A}	0.4937
Adenosine + Urea	On	7.7 b^{A}	7.8 a^{A}	7.8 a^{A}	7.8 bc^{A}	0.1326
6-BA + Urea	On	7.8 ab^{A}	7.8 b^{A}	7.8 a^{A}	7.7 bc^{A}	0.6412
Bearing Shoots						
Control	Off	7.7 ab^{AB}	7.9 a^{A}	7.7 a^{B}	7.7 c^{B}	0.0727
Adenosine	Off	7.8 ab^{A}	7.8 a^{A}	7.7 a^{A}	7.7 c^{A}	0.5657
Control	On	7.8 ab^{A}	7.8 a^{A}	7.8 a^{A}	7.8 abc^{A}	0.9885
Adenosine + Urea	On	8.0 a^{A}	8.0 a^{A}	8.0 a^{A}	8.0 a^{A}	0.5700
6-BA + Urea	On	8.0 a^{A}	8.0 a^{A}	8.0 a^{A}	8.0 ab^{A}	0.5459
P-value		0.2219	0.3993	0.2945	0.0429	
		Number of Lateral Vegetative Shoots				
Nonbearing shoots						
Control	Off	3.4 a^{B}	4.6 ab^{A}	4.8 ab^{A}	3.9 abc^{AB}	0.0255
Adenosine	Off	3.2 abc^{B}	4.3 abc^{A}	4.1 abc^{A}	4.0 abc^{A}	0.0032
Control	On	2.1 cd^{B}	5.7 a^{A}	5.2 a^{A}	4.9 a^{A}	<0.0001
Adenosine + Urea	On	1.7 d^{B}	4.0 bcd^{A}	4.2 abc^{A}	4.5 ab^{A}	<0.0001
6-BA + Urea	On	1.9 d^{B}	4.5 ab^{A}	4.3 abc^{A}	3.7 abc^{A}	0.0002
Bearing Shoots						
Control	Off	3.2 ab^{A}	4.0 bcd^{A}	3.6 bcd^{A}	3.0 cde^{A}	0.1103
Adenosine	Off	3.6 a^{A}	4.0 bcd^{A}	3.3 cde^{A}	3.4 bcd^{A}	0.1070
Control	On	1.8 d^{A}	2.8 cde^{A}	2.1 ef^{A}	1.9 ef^{A}	0.0521
Adenosine + Urea	On	2.1 bcd^{A}	2.6 de^{A}	2.7 def^{A}	2.4 def^{A}	0.1187
6-BA + Urea	On	1.5 d^{A}	2.1 e^{A}	1.9 f^{A}	1.7 f^{A}	0.3782
P-value		0.0002	0.0004	<0.0001	<0.0001	
		Number of Buds that Abscised				
Nonbearing shoots						
Control	Off	3.2 b^{B}	4.4 cd^{A}	4.8 d^{A}	4.9 c^{A}	0.0047
Adenosine	Off	5.3 a^{A}	5.7 bc^{A}	5.8 cd^{A}	6.0 c^{A}	0.3730
Control	On	1.6 b^{A}	1.4 e^{A}	1.6 e^{A}	1.4 d^{A}	0.8634
Adenosine + Urea	On	1.9 b^{A}	2.5 e^{A}	2.3 e^{A}	2.5 d^{A}	0.4210
6-BA + Urea	On	2.7 b^{A}	2.8 de^{A}	3.0 e^{A}	2.9 d^{A}	0.9558
Bearing Shoots						
Control	Off	5.9 a^{C}	8.6 a^{B}	8.6 ab^{B}	9.9 a^{A}	<0.0001
Adenosine	Off	6.3 a^{B}	8.0 a^{A}	9.1 a^{A}	9.0 ab^{A}	0.0006
Control	On	6.0 a^{B}	6.9 ab^{AB}	7.8 ab^{A}	7.8 b^{A}	0.0011
Adenosine + Urea	On	6.2 a^{B}	7.3 ab^{A}	6.9 bc^{AB}	7.8 b^{A}	0.0281
6-BA + Urea	On	6.7 a^{B}	7.9 a^{A}	7.8 ab^{A}	8.2 ab^{A}	0.0059
P-value		<0.0001	<0.0001	<0.0001	<0.0001	

		Number of Inactive Buds				
Nonbearing shoots						
Control	Off	9.1 b^{A}	6.9 bc^{B}	6.1 b^{B}	7.0 bc^{B}	0.0023
Adenosine	Off	7.5 b^{A}	5.8 c^{B}	5.8 b^{B}	5.9 c^{B}	0.0041
Control	On	12.0 a^{A}	8.6 ab^{B}	8.8 a^{B}	9.3 a^{B}	0.0008
Adenosine + Urea	On	11.7 a^{A}	9.2 a^{B}	9.1 a^{B}	8.5 ab^{B}	0.0004
6-BA + Urea	On	11.1 a^{A}	8.2 ab^{B}	8.3 a^{B}	8.9 a^{B}	0.0014
Bearing Shoots						
Control	Off	5.0 c^{A}	1.8 d^{B}	2.2 c^{B}	1.6 d^{B}	<0.0001
Adenosine	Off	3.9 c^{A}	2.1 d^{B}	1.7 c^{B}	1.7 d^{B}	0.0031
Control	On	3.7 c^{A}	2.6 d^{B}	2.5 c^{B}	2.5 d^{B}	0.0463
Adenosine + Urea	On	3.8 c^{A}	2.7 d^{B}	3.0 c^{AB}	2.5 d^{B}	0.0382
6-BA + Urea	On	3.6 c^{A}	1.9 d^{B}	2.4 c^{B}	2.2 d^{B}	0.0090
P-value		<0.0001	<0.0001	<0.0001	<0.0001	
		Number of Nodes Bearing Fruit				
Nonbearing shoots						
Control	Off	0.0 c^{A}	0.0 d^{A}	0.0 c^{A}	0.0 c^{A}	.
Adenosine	Off	0.0 c^{A}	0.0 d^{A}	0.0 c^{A}	0.0 c^{A}	.
Control	On	0.0 c^{A}	0.0 d^{A}	0.0 c^{A}	0.0 c^{A}	.
Adenosine + Urea	On	0.0 c^{A}	0.0 d^{A}	0.0 c^{A}	0.0 c^{A}	.
6-BA + Urea	On	0.0 c^{A}	0.0 d^{A}	0.0 c^{A}	0.0 c^{A}	.
Bearing Shoots						
Control	Off	1.4 b^{A}	1.4 c^{A}	0.9 b^{B}	0.9 b^{B}	0.0079
Adenosine	Off	1.8 b^{A}	1.5 c^{AB}	1.2 b^{B}	1.2 b^{B}	0.0088
Control	On	4.1 a^{A}	3.5 ab^{B}	3.3 a^{B}	3.4 a^{B}	0.0003
Adenosine + Urea	On	3.8 a^{A}	3.4 b^{A}	3.3 a^{A}	3.4 a^{A}	0.1575
6-BA + Urea	On	4.3 a^{A}	4.1 a^{A}	3.9 a^{A}	3.8 a^{A}	0.1502
P-value		<0.0001	<0.0001	<0.0001	<0.0001	
		Number of Fruit				
Nonbearing shoots						
Control	Off	.	.	0.0 c^{A}	0.0 c^{A}	.
Adenosine	Off	.	.	0.0 c^{A}	0.0 c^{A}	.
Control	On	.	.	0.0 c^{A}	0.0 c^{A}	.
Adenosine + Urea	On	.	.	0.0 c^{A}	0.0 c^{A}	.
6-BA + Urea	On	.	.	0.0 c^{A}	0.0 c^{A}	.
Bearing Shoots						
Control	Off	.	.	1.9 b^{A}	1.9 b^{A}	0.9614
Adenosine	Off	.	.	2.2 b^{A}	2.2 b^{A}	0.9577
Control	On	.	.	5.1 a^{A}	5.2 a^{A}	0.4159
Adenosine + Urea	On	.	.	5.1 a^{A}	5.5 a^{A}	0.1630
6-BA + Urea	On	.	.	5.7 a^{A}	5.9 a^{A}	0.4859
P-value		.	.	<0.0001	<0.0001	

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Table 4. Effect of crop load and foliar applied cytokinins +/- urea on the fate of buds on the basal 8 node pairs along a mature vegetative shoot of ‘Manzanillo’ olive trees in Exeter, CA.

Treatment	Status	June	July	August	September	*P*-value
		Number of Node Pairs				
Nonbearing shoots						
Control	Off	6.5 a^{Az}	5.3 abc^{A}	5.2 ab^{A}	5.1 abc^{A}	0.0005
Adenosine	Off	5.9 abc^{A}	5.7 ab^{A}	5.4 ab^{B}	5.3 ab^{B}	0.2167
Control	On	5.8 abcd^{A}	5.7 ab^{AB}	4.9 abc^{AB}	4.8 abc^{B}	0.0037
Adenosine + Urea	On	5.6 abcd^{A}	5.3 abc	4.8 abc	4.7 abc	0.0937
6-BA + Urea	On	5.3 bcd^{A}	4.7 bc^{AB}	4.1 cd^{B}	4.0 cd^{B}	0.0013
Bearing Shoots						
Control	Off	5.0 cd^{A}	4.2 c^{B}	3.7 d^{B}	3.6 d^{B}	0.0007
Adenosine	Off	4.7 d^{A}	4.3 c^{A}	4.4 bcd^{A}	4.4 bcd^{A}	0.5671
Control	On	6.4 ab^{A}	5.5 ab^{B}	5.1 abc^{B}	5.2 ab^{B}	0.0031
Adenosine + Urea	On	6.2 ab^{A}	5.6 ab^{B}	5.6 a^{B}	5.5 a^{B}	0.0766
6-BA + Urea	On	6.2 ab^{A}	5.9 a^{AB}	5.5 a^{BC}	5.3 ab^{C}	0.0137
P-value		0.0210	0.0186	0.0081	0.0058	
		Number of Lateral Vegetative Shoots				
Nonbearing shoots						
Control	Off	1.8 b^{A}	2.0 a^{A}	1.7 a^{A}	1.6 a^{A}	0.4029
Adenosine	Off	1.9 ab^{A}	2.0 a^{A}	2.2 a^{A}	2.2 a^{A}	0.3840
Control	On	1.2 b^{B}	2.1 a^{A}	2.2 a^{A}	2.1 a^{A}	0.0232
Adenosine + Urea	On	1.0 b^{B}	1.8 a^{A}	1.4 a^{AB}	1.5 a^{AB}	0.0947
6-BA + Urea	On	1.0 b^{A}	1.6 a^{A}	1.3 a^{A}	1.3 a^{A}	0.4160
Bearing Shoots						
Control	Off	1.8 ab^{A}	1.7 a^{A}	1.6 a^{A}	1.8 a^{A}	0.7033
Adenosine	Off	2.7 a^{A}	2.5 a^{A}	2.4 a^{AB}	2.0 a^{B}	0.0549
Control	On	1.8 b^{A}	2.1 a^{A}	1.6 a^{A}	1.3 a^{A}	0.1159
Adenosine + Urea	On	1.9 ab^{A}	1.7 a^{A}	1.9 a^{A}	1.8 a^{A}	0.7733
6-BA + Urea	On	1.1 b^{A}	1.6 a^{A}	1.4 a^{A}	1.4 a^{A}	0.7066
P-value		0.0071	0.8499	0.4025	0.3137	
		Number of Buds that Abscised				
Nonbearing shoots						
Control	Off	4.3 a^{A}	4.3 a^{A}	4.9 a^{A}	4.7 b^{A}	0.5886
Adenosine	Off	4.8 a^{A}	5.2 a^{A}	5.3 a^{A}	5.2 ab^{A}	0.7248
Control	On	2.0 b^{A}	1.9 b^{A}	1.8 b^{A}	1.4 c^{A}	0.6118
Adenosine + Urea	On	2.3 b^{A}	2.4 b^{A}	2.9 b^{A}	2.7 c^{A}	0.5538
6-BA + Urea	On	1.9 b^{A}	2.5 b^{A}	2.4 b^{A}	2.2 c^{A}	0.5235
Bearing Shoots						
Control	Off	5.8 a^{A}	5.6 a^{A}	4.7 a^{A}	5.0 ab^{A}	0.2234
Adenosine	Off	4.7 a^{C}	5.2 a^{BC}	5.9 a^{AB}	6.2 a^{A}	0.0164
Control	On	4.8 a^{A}	5.1 a^{A}	4.8 a^{A}	5.2 ab^{A}	0.9223
Adenosine + Urea	On	4.6 a^{A}	5.6 a^{A}	5.4 a^{A}	5.6 ab^{A}	0.1463
6-BA + Urea	On	5.5 a^{A}	5.7 a^{A}	5.7 a^{A}	6.4 a^{A}	0.1369
P-value		<0.0001	<0.0001	<0.0001	<0.0001	

		Number of Inactive Buds				
Nonbearing shoots						
Control	Off	7.1 ab^{A}	4.2 cd^{B}	3.8 bc^{B}	3.9 bcd^{B}	<0.0001
Adenosine	Off	5.2 bc	4.2 cd	3.2 c	3.2 cd	0.0038
Control	On	8.4 a^{A}	7.4 a^{AB}	5.7 a^{B}	6.0 a^{B}	0.0026
Adenosine + Urea	On	7.9 a^{A}	6.3 ab^{AB}	5.4 ab^{C}	5.2 ab^{BC}	0.0130
6-BA + Urea	On	7.7 a^{A}	5.3 bc^{AB}	4.4 abc^{B}	4.5 abc^{B}	0.0002
Bearing Shoots						
Control	Off	2.2 d^{A}	1.0 e^{B}	1.1 d^{B}	0.4 e^{B}	0.0012
Adenosine	Off	1.8 d^{A}	0.9 e^{B}	0.5 d^{B}	0.5 e^{B}	0.0006
Control	On	5.3 bc^{A}	3.1 d^{B}	3.4 c^{B}	3.5 cd^{B}	<0.0001
Adenosine + Urea	On	4.6 c^{A}	2.9 d^{B}	3.2 c^{B}	2.9 d^{B}	0.0056
6-BA + Urea	On	4.5 c^{A}	3.6 cd^{AB}	3.2 c^{BC}	2.3 d^{C}	0.0015
P-value		<0.0001	<0.0001	<0.0001	<0.0001	
		Number of Nodes Bearing Fruit				
Nonbearing shoots						
Control	Off	0.0 b^{A}	0.0 b^{A}	0.0 b^{A}	0.0 b^{A}	.
Adenosine	Off	0.0 b^{A}	0.0 b^{A}	0.0 b^{A}	0.0 b^{A}	.
Control	On	0.0 b^{A}	0.0 b^{A}	0.0 b^{A}	0.0 b^{A}	.
Adenosine + Urea	On	0.0 b^{A}	0.0 b^{A}	0.0 b^{A}	0.0 b^{A}	.
6-BA + Urea	On	0.0 b^{A}	0.0 b^{A}	0.0 b^{A}	0.0 b^{A}	.
Bearing Shoots						
Control	Off	0.2 b^{A}	0.1 b^{AB}	0.1 b^{B}	0.0 b^{B}	0.0397
Adenosine	Off	0.2 b^{A}	0.1 b^{A}	0.0 b^{A}	0.1 b^{A}	0.4157
Control	On	0.9 a^{A}	0.7 a^{AB}	0.5 a^{B}	0.5 a^{B}	0.0180
Adenosine + Urea	On	1.3 a^{A}	1.0 a^{AB}	0.6 a^{B}	0.7 a^{B}	0.0154
6-BA + Urea	On	1.3 a^{A}	0.9 a^{AB}	0.6 a^{B}	0.6 a^{B}	0.0128
P-value		<0.0001	<0.0001	<0.0001	<0.0001	
		Number of Fruit				
Nonbearing shoots						
Control	Off	.	.	0.0 b^{A}	0.0 b^{A}	.
Adenosine	Off	.	.	0.0 b^{A}	0.0 b^{A}	.
Control	On	.	.	0.0 b^{A}	0.0 b^{A}	.
Adenosine + Urea	On	.	.	0.0 b^{A}	0.0 b^{A}	.
6-BA + Urea	On	.	.	0.0 b^{A}	0.0 b^{A}	.
Bearing Shoots						
Control	Off	.	.	0.1 b^{A}	0.0 b^{A}	0.2637
Adenosine	Off	.	.	0.1 b^{A}	0.1 b^{A}	0.3343
Control	On	.	.	0.7 a^{A}	0.7 a^{A}	0.8849
Adenosine + Urea	On	.	.	1.1 a^{A}	1.1 a^{A}	0.6960
6-BA + Urea	On	.	.	0.9 a^{A}	0.9 a^{A}	0.8062
P-value		.	.	<0.0001	<0.0001	

[z] Values in a vertical column followed by different lower case letters and horizontal row followed by different uppercase superscript letters are significantly different at *P*-value specified by Fisher's Protected LSD Test.

UNIVERSITY OF CALIFORNIA, DAVIS
Accounting Office
Extramural Accounting
Contractor's Invoice

Please include the following claim number on your remittance advice.
Claim No. XB05193

INVOICE TO
CA OLIVE COMMITTEE
770 E SHAW, SUITE 310
FRESNO, CA 93710

Invoice Number: 28003-2
Date: October 15, 2014
Amount: $7,294.80

e-mail: denise@calolive.org

Questions regarding this invoice should be directed to Eli Berici @ (530) 752-5618 or eberici@ucdavis.edu

Federal Employee ID # 94-6036494		Period Billed	
Contract/Grant/Agreement/Purchase Order	# 201402127	From 01/15/14	To 12/31/14

Project Title:	**Investigation of High Temperature Effects on Olive Fruit Set: Structural and Developmental Aspects of Pollen Tube Growth**
PI /Director:	**Judy Jernstedt**
Department:	**Plant Sciences**

Description of Services			CURRENT
PER TERMS OF AGREEMENT			
Award Amount:	**$18,237.00**		
20% Due no later than July 15, 2014 The budget for the first 20% of this project has been spent on Supplies and Expenses			
40% Due upon receipt of progress report			$7,294.80
40% Due upon receipt of final report			

Please Return Invoice Copy with Check

PAY THIS AMOUNT>>>>> **$7,294.80**

Remarks:
OUTSTANDING INVOICES

Barbara Gp[illegible]

James Ringo/eb Division Manager

Make Check Payable and Mail To:
The Regents of The University of California
Cashier's Office
University of California, Davis
P.O. Box 989062
West Sacramento, CA 95798-9062

To the best of my knowledge and belief this report is correct and complete and all outlays are for the purposes set forth in the award documents.

Progress Report - July 2014

Project Leader: Judy Jernstedt, Professor Location: 212 Hunt Hall

Mailing Address: Plant Sciences, Mail Stop 1, UC Davis, Davis, CA 95616

Phone: 530-752-7166 FAX: 530-752-4361 E-mail: jjernstedt@ucdavis.edu

Project Title: Investigation of high temperature effects on olive fruit set: Structural and developmental aspects of pollen tube growth (Research Priority: PGRs, with Focus on Pistils)

Cooperating Personnel: **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

Keywords: pistils, style, stigma, pollen, pollen tube, fruit set

Spring 2014: Beginning 21 April 2014 and continuing through 1 May 2014, we emasculated and bagged perfect flowers of six mature Manzanillo olive trees located on Hutchison Drive, Davis, CA 95616. A total of 180 tissue paper bags were attached, each containing 1or 2 emasculated flowers. At the end of the bagging, an unseasonably hard rain hit Davis and most of the bags were torn open by subsequent strong wind. Emasculated flowers in the eight surviving intact bags were pollinated with Manzanillo pollen.

At intervals during the first half of May, hand-pollinated and open-pollinated Manzanillo flowers were collected, chemically fixed, and dehydrated in an ethanol dilution series. They are now ready to be processed for embedding and sectioning. In addition, multiple flowers at six developmental stages (unopened bud, open flower with closed anthers, anthers split open, etc.) were collected from a single tree of Morcal (tree A-9-3) olives growing at the USDA Clonal Germplasm Repository Wolfskill orchard in Winters, CA. These samples were fixed and dehydrated, and are now ready to be processed for embedding in resin for sectioning and staining (histochemical and immunocytochemical staining). The undergraduate lab assistant is working 10-15 hours per week to accomplish the sectioning and staining part of the project. The goal is to have some results and photomicrographs by the middle of August 2014.

Sub Fund Summary by Consolidation (FIS55)

DaFIS Decision Support >> Fund Source Summary Reports >> Sub Fund Summary by Consolidation >> Report Output

Jump to account: 3-9228003 | 3-28003UB | 3-APSPO12

Through Fiscal Period:	October, 2014	Previous Month	Next Month
Chart(s):	3,L,S	Totals On This Report Are:	Year To Date (click to toggle)
OP Fund:	28003		

Sub Fund Group	OP Fund Account	Obj. Consol			Appropriation	Expenditure	Encumbrance	Balance
PRCONT - PRIVATE CONTRACTS								
28003 - CALIFORNIA OLIVE COMMITTEE-201402127		OP Fund Award #: 201402127		Award End Date: 12/31/2014 Fund Manager: DAWA,ROBERT HENRY				
	Originating Office:OVCR-201402127							
	3-9228003							
	Account Manager: DAWA,ROBERT HENRY	INC:CALIFORNIA OLIVE COMM		PI: JERNSTEDT,JUDY				
	Higher Ed.:	NIH:	Pmt. Method: 50	ICR: D000				
	Acct. Award #: 201402127	Acct. Award End Date:	12/31/2014	LOC Group:				
		INC0	INCOME		18,237.00	3,647.40CR	0.00	14,589.60OD
	Total Account:				18,237.00	3,647.40CR	0.00	14,589.60OD
	3-28003UB							
	Account Manager: DAWA,ROBERT HENRY	UBA:CALIFORNIA OLIVE COMM		PI: JERNSTEDT,JUDY				
	Higher Ed.:	NIH:	Pmt. Method: 50	ICR: D000				
	Acct. Award #:	Acct. Award End Date:	12/31/2014	LOC Group:				
		BLSH	BALANCE SHEET		0.00	0.00	0.00	0.00
	Total Account:				0.00	0.00	0.00	0.00
	3-APSPO12							
	Account Manager: CLEARWATER,KERRY P	PS: COC: 13-14: JERNSTEDT		PI: JERNSTEDT,JUDY				
	Higher Ed.: ORES	NIH:	Pmt. Method: 50	ICR: B110				
	Acct. Award #: 201402127	Acct. Award End Date:	12/31/2014	LOC Group:				
		SUBG	GENERAL ASSISTANCE		10,000.00CR	289.56	0.00	9,710.44CR
		SUB3	SUPPLIES AND EXPENSE		6,000.00CR	2,687.42	865.17	2,447.41CR
		SUB5	TRAVEL		300.00CR	0.00	0.00	300.00CR
		SUB6	EMPLOYEE BENEFITS		130.00CR	3.76	0.00	126.24CR
	Account Direct Costs Sub-Total:				16,430.00CR	2,980.74	865.17	12,584.09CR
		INDR	INDIRECT COSTS		1,807.00CR	327.89	0.00	1,479.11CR
	Total Account:				18,237.00CR	3,308.63	865.17	14,063.20CR
	Total Fund 28003:				0.00	338.77CR	865.17	526.40OD
Total Sub-Fund Group:					0.00	338.77CR	865.17	526.40OD
Total Groups:					0.00	338.77CR	865.17	526.40OD

Billing For Fixed Installment Payment

JV # 34098967

PR–

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Template: /DecisionSupport/financial/subfundsummary.cfm ($Revision: 1.7.2.9 $$Date: 2013/05/22 23:28:19 $)
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