CALIFORNIA OLIVE COMMITTEE

FINAL REPORT – YEAR 1

Workgroup/Department: Olive / Plant Sciences College of Agriculture, CSU Chico

Project Year 2016-17 Anticipated Duration of Project: 4 years

Project Title: Canopy management, tree hedging and topping to optimize yield

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Commodity: Olive Relevant CSUC Project No.

Year Initiated: 2016 Current Funding Request: **31,075.00**

Introduction and scope

Mechanical hedging and topping can be important tool in improving harvest efficiencies by affecting return bloom, helping to maintain trees in their allotted space and reducing hand pruning costs. Typically, hedging and topping result in smaller and more compact trees. Smaller trees will facilitate hand harvest by obviating the need for tall, cumbersome ladders and likely increasing the number of bins harvested per hour. Picking crews have repeatedly commented that they prefer to harvest from mechanically hedged and topped trees than from traditionally pruned trees (Louise Ferguson, personal communication). In oil olive orchards, mechanical hedging has resulted in increased harvest efficiency and reduced alternate bearing (Charlie Garcia, California Olive Ranch Manager, personal communication). However, timing of mechanical hedging is critical for optimal yields. Hedging too late in the season may not provide enough time for new shoots to grow and flower buds to initiate. Earlier work that we conducted

on 'Arbequina' oil olives indicated that shoot growth that occurred after early July did not produce flowers the following year. Whether 'Manzanillo' olives will behave the same is unknown. Hedging too early in the season can cause extensive vegetative growth at the expense of fruit growth. Thus, finding 'the sweet spot' for the timing of mechanical hedging is important to maximize and help regulate yields.

Materials, methods and results

Experiment 1: Mechanical Hedging (Erik Nielsen's Orchard)

Hypothesis: optimal timing or mechanical hedging will not decrease yield and will facilitate mechanical harvesting.

Overall Objective: to determine the optimal timing of mechanical hedging for table olive productivity and fruit quality.

2016 Objectives:

I. Hedge Trees Monthly from April to July
II. Evaluate effect of pruning treatments on shoot growth, and return bloom and quality: perfect versus imperfect flowers.
III. Evaluate effect of pruning treatments on yield and fruit quality.
IV. Determine optimal timing of hedging treatment to facilitate high quality fruit production and return bloom.

The experiment was established as a randomized block design with four blocks in a 14-year-old orchard at Erik Nielsen's farm (Figure 1). Because of the late start of the grant, we were not able to hedge early in the spring; next year we will initiate hedging treatments in March. In 2016, hedging began on April 27 and continued approximately monthly until mid-July. In 2017, two hedging treatments occurred on 3/1 and 3/29/17. A video of the severe hedging can be found at https://photos.google.com/search/_tv_Videos/photo/AF1QipNCE1VGj7inFN8TkIWPMs_1BOKg_5QN2Mgg2y9Z.

Light interception levels were determined using a Decagon quantum sensor following hedging (Figure 2). We also used a light mule developed at UC Davis to determine light interception (Figure 3). Hedging significantly decreased the canopy size from 10 to 25% compared with the non-hedged control (Table 1). This could be a problem because, tree canopy light interception is linearly related to yield (i.e. the more light interception the more crop yield) in many orchard crops. However, we did find a yield reduction in moderately hedged trees in this trial.

The greatest yields were found in the earliest and moderately hedged plots (Table 1). Severe hedging and hedging conducted earlier in the season also resulted in larger fruit and greater price per ton. However, similar to the Nickels trial, the greater price per ton could not compensate for the lower yields caused by the severe hedging that removed fruit-bearing wood. We suspect that the highest and lowest yielding treatments will trade places the following year due to the alternate bearing nature of the olive. Hedging, however, should reduce the severity of the

alternate bearing. We will be evaluating the effects of the timing and severity of hedging on returns bloom and yield in 2017.

We measured shoot growth on stems adjacent to the hedging wound to assess the effects of hedging dates on growth and return bloom (Figure 4). Both shoot growth and number of inflorescences per shoot decreased linearly with later hedging dates. Preliminary data indicate that the earlier in the season the trees are hedged the greater the shoot growth and return bloom the following year.

Experiment 2: Mechanical Topping

Materials and Methods:
Experimental Plot: Nickels Estate - 2 acre 'Manzanillo' orchard established in 2002.

Hypothesis: mechanically topping hedgerow olive orchards will not decrease yield and will reduce hand harvesting costs by producing shorter statured trees.

Overall Objective: to determine the optimal row height for table olive productivity and fruit quality at a 12 X 18' orchard spacing (202 trees/acre) and develop the formulas for applying this information to different latitudes and orchard spacing.

2016 Objectives:

I. Apply two different tree height pruning treatments and compare to controlling tree height with hand pruning
II. Install sunlight exposure monitoring equipment
III. Evaluate effect of pruning treatments on bloom quality: perfect versus imperfect.
IV. Evaluate effect of pruning treatments on yield and fruit quality in upper and lower canopy at harvest.

We initiated the trial in late April 2016 (Figure 5) as a randomized block design with 3 treatments and 4 replicates. The treatments were: a) 10 foot topping, b) 13 foot topping and c) control – no topping. All trees were hedged on April 25 followed by hand pruning on May 26. We measured the time it took for seven pruners to prune 30 trees in all treatments to estimate pruning costs. The 10-foot topping treatment removed significant amounts of wood and produced shorter statured trees (Figure 2). Trees were harvested on October 7, 2016 and samples were taken to Musco Olive to evaluate fruit size and value of the crop.

Pruning costs, crop yields, price (based on the grading sheet) and partial economic return (calculated as the product of yield and price with pruning costs subtracted) are presented in Table 1. Trees that were topped at 10 feet resulted in pruning costs that were about half the non-topped control in 2016. In 2017, the 10-foot topping treatment lowered pruning costs 22% compared with the non-topped control. All pruning was conducted from the ground using poll saws on these smaller trees; no ladders were needed.

No significant differences ($p < 0.05$) were found between olive yields; however, there was a trend that topping reduced yields. Trees topped at 10 and 13 feet produced larger fruit than the

control, resulting in a great price per ton (Table 1). This greater value, however, could not compensate for the lower olive yields. The partial economic returns were greatest in the control treatment. Bloom appears heavy in 2017, especially in the 10-foot topping treatment. We will be measuring yields again in 2017.

Experiment 3: Mechanical Hedging (Heath Burreson's Orchard)

The goals of this experiment are similar to the Nielsen trial (Figure 5): 1) determine the most effective timing of canopy hedging, and 2) evaluate hedging effects on return bloom and alternate bearing. Trees were planted in 2010 at a 12' x 18' spacing with rows a north/south direction to maximize light interception. (Please Note: the Nielsen trial was planted in an east/west direction, so well will be able to compare the effects of hedging trees on both orchard orientations). The experiment consists of monthly hedging treatments starting March and ending in June with 10 replicates. Ten replicates will increase the precision of the experiment and reduce orchard variability. To date, the March, April, and May hedging treatments have been conducted.

Olive Nutrient Removal Calculator

'Manzanillo' olives from various orchards have been collected, dried, ground, and analyzed for nutrient content. Samples will be taken again in 2017 and incorporated into a nutrient removal calculator for 'Manzanillo' olives, please see http://www.csuchico.edu/~rrosecrance/Model/OliveCalculator/OliveCalculator.html.

We will be collecting light levels in orchards using the Decagon light bar, Hobo quantum sensors, and the UC Davis Light Mule during the 2017 growing season. These data and shoot growth measurements will be used to assess the regrowth of the orchard following hedging treatments.

Desired Results:

To determine how canopy management with mechanical topping and hedging affects total hours of canopy light exposure and therefore flower production, fruit yield and quality. The ultimate goal is to demonstrate how to calculate the optimal tree height for moderate density orchards at different latitudes. We are making good progress on the goals of this project.

Figure 1. Set up of Nielsen trial in Orland, California. Colors correspond to the following hedging dates:
Black = 27-Apr Blue = 15-Jul Severe Blue Pokadot= 24-May Severe
Green = 24-May Pink = 27-Apr Severe White = Control

Figure 2. Measuring light levels following hedging using a quatum sensor

Photo curtesy of Dr. Lampinen

Figure 3. Light mule which measures midday canopy photosynthetically active radiation (PAR) interception in orchards.

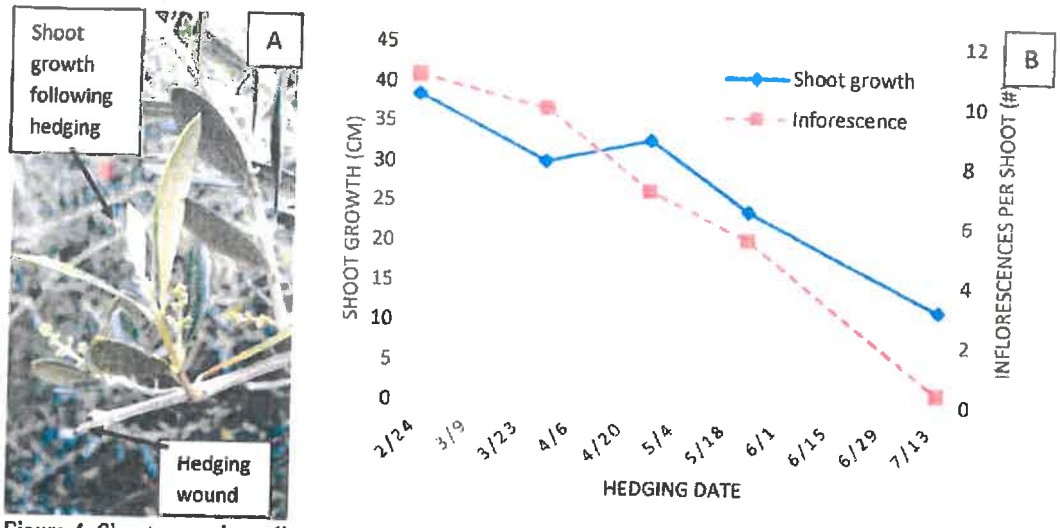

Figure 4. Shoots growing adjacent to the hedging wound (A) and shoot growth and number of inflorescences from shoots adjacent to hedging wound at various hedging dates in 2016 (B). Measurements were take on 4/12/17.

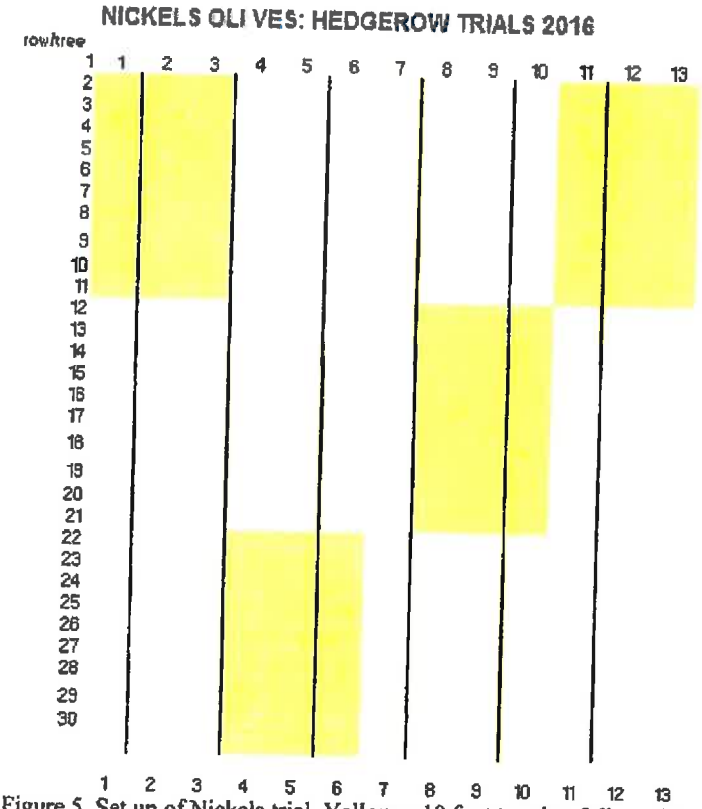

Figure 5. Set up of Nickels trial. Yellow = 10 foot topping followed by hand pruning to remove stubs with thinning cuts; Green = 13 foot topping followed by hand pruning to thin canopy and remove stubs; Blue = Hand pruned. Solid line represents where double boom hedger traveled in May 25, 2016 (5 feet from trunk).

Figure 6. Trees following 10 foot topping and hedging 5 feet from the trunk.

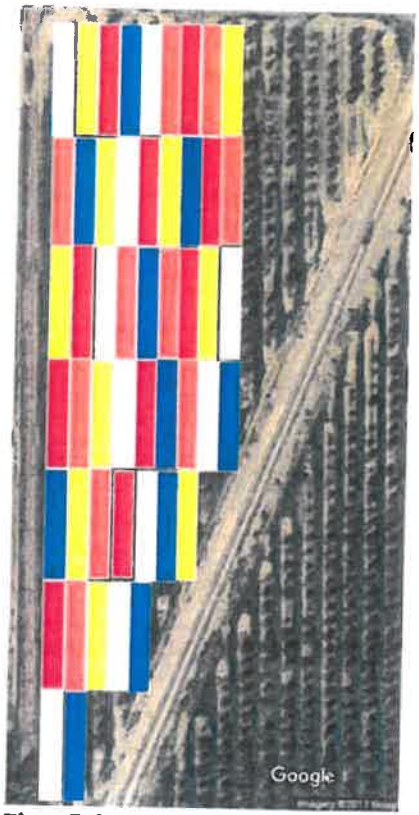

Figure7. Set up of trial in Orland, California, in Spring 2017 (Heath Burreson's orchard). Colors correspond to the following hedging dates: White = Control (no hedging); Yellow = 8-Mar; Red = 5-Apr; Blue = 8-May; Orange = 8-Jun.

Table 1. Effects of hedging date and severity of hedging on 'Manzanillo' olive yields at Nielsen's farm.

Hedging Date	Severity of Hedge*	% Light Interception	Yield (lbs/a)	Price ($/t)
24-May	Moderate	74 b	14533 a	1171
27-Apr	Moderate	76 b	14313 a	1238
No Hedge	NA	85 c	13246 a	1184
24-May	Severe	61 a	12203 ab	1194
15-Jul	Severe	68 ab	12070 ab	1227
15-Jul	Moderate	73 b	10528 ab	1235
27-Apr	Severe	71 b	6183 b	1270
P value		0.037	0.041	NS

* Moderate = approximately 8.5 feet from trunk; Severe = approximately 6.5 feet from trunk

Table 2. Relationship between topping height and pruning costs, 'Manzanillo' olive yields, fruit value, and return at Nickels farm in 2016 and 2017.

Treatment	Pruning Costs (2017)* ($/a)	Pruning Costs (2016) ($/a)	Yields (t/a)	Price ($/ton)	Return*** ($/a)
Topped at 10'	345 a	500 a**	2.01	1336 a	2066
Topped at 13'	461 b	885 b	3.57	1326 a	3161
Control	442 b	930 b	4.65	1217 b	4715
P value	0.036	0.045	0.091	0.0004	0.1

* pruning costs based on time needed to prune the trees multiplied by $16/hr, including overhead.
** different letters in the same column indicate significance $p < 0.05$.
** partial economic return was calculated as the product of yield and price with pruning costs subtracted, no other costs were included