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UC CE

Olive Notes
Tulare County

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Olive Grower's Council
UCCE Pre-harvest Olive Day Meeting

Wednesday September 4, 2013
Exeter Memorial Building
324 N. Kaweah Ave., Exeter, CA 93221

7:30 am	**Registration**
8:00	**Welcome,** *Adin Hester and Elizabeth Fichtner*
8:05	**State of Table Olive Industry,** *Adin Hester, President, Olive Grower's Council*
8:15	**Introducing the New Electronic Reporting System for Table Olives,** *Denise Junqueiro, Director of Programs, California Olive Committee*
8:35	**Industry Progress on Leveling the Field for Competition with Imported Oil,** *Kyle Sawatzky, President, Bari Olive Oil Company; President, California Olive Oil Council (COOC); Board member, American Olive Oil Producers Association (AOOPA)*
9:00	**Research Update Disease Management and Mitigation of Alternate Bearing in Olive,** *Elizabeth Fichtner, Farm Advisor, UCCE Tulare County*
9:30	**Progress on the Mechanical Harvest of Table Olives,** *Louise Ferguson, UC Extension Specialist, Plant Science*
10:00	**Break and Trade Show**
10:30	**Potential for Olive Fruit Fly Management with Attract and Kill Traps in California Table Olive Orchards,** *Vicky Yokoyama, Entomologist, USDA, ARS, Parlier, CA*
11:00	**Weed Management Update for Olive and Other Orchard Crops,** *Brad Hanson, UC Extension Specialist Weed Science*
11:30	**Resources Available for Growers Victimized by AG Crimes,** *Sgt. John Dow, Sheriff's Office*
12:00 pm	**The Evolution of Oliviculture,** *Umberto Chironi Lubelli, Olivi Nursery*
12:15	**Factors Affecting the Price of Olives,** *Rod Burkett, Chairman of the Board, Olive Grower's Council*
12:30	**Lunch**

Meeting Sponsors:

Olive Grower's Council, UCCE Tulare County, West Coast Olive Guide, California Olive Committee, Musco Family Olive Co., Bell Carter Olive Co., Olivi Nursery, LLC., AgriLogic Insurance

PCA Credit Requested: 1.5 Hours CCA Credit Requested: 2 Hours

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U.S. Department of Agriculture, University of California, and Tulare County Cooperating

Innovative Progress in the Mechanical Harvest of California Black Ripe Olives

Introduction

The economic sustainability and consequent longevity of California's historic "black ripe" table olive industry is challenged by the crippling cost of hand-harvest, a cost that often exceeds 50-75% of gross return. Hand harvest costs are volatile due to dynamics in annual and regional crop load and labor supply, and are also influenced by competition between growers and producers of other commodities. Development of a mechanical harvesting method offers the only economically-feasible solution to long-term industry sustainability. Three interrelated factors contribute to successful development of mechanical harvest technologies: i) design of fruit-removal and catch methods that do not adversely affect fruit or tree, ii) tree training and pruning to facilitate mechanized harvest, and iii) design or discovery of abscission agents to enhance fruit loosening and removal from the tree. Although an abscission agent has yet to be found, fruit removal technologies and tree training innovations have fostered the advent of mechanical harvest for the table olive industry.

Impediments to Mechanical Harvest

Both the botany of the olive and industry processing standards impose impediments to implementation of mechanical harvest. 'Manzanillo' olives, the major cultivar utilized for black ripe processing, are harvested when physiologically immature; consequently, they require a higher "pull force" (~0.5 kg) for removal then mature fruit. Most traditional CA table olive orchards are comprised of tall trees (≥ 18 ft) with wide canopies (12-18 ft), and fruit is borne on the ends of multiple flexible pendulous shoots. Additionally, the fruit bruise easily, and excess damage adversely affects fruit value and grower return.

Developing and Evaluating Mechanical Harvesters

A multi-phase sequence is generally employed for either development of a new mechanical harvester or adaptation of an existing harvest technology from another crop. Fruit removal techniques are developed and then tested to ensure lack of damage to the commodity and the tree. Then a mobile platform is built to hold the driver and a catch frame and the final unit is tested for harvester efficiency and operating parameters (i.e. ground speed, harvest rate, etc). Harvester efficiency is best conceptualized in comparison to hand harvest, with hand harvest considered to achieve nearly 100% fruit removal, an overestimate-but appropriate standard for comparison. University of California Agricultural Economist, Dr. Karen Klonsky, estimates that a mechanical harvesting cost of $150/ton requires approximately 80% final harvester efficiency for economic feasibility. Studies conducted on two harvesters in 2012 suggest that harvester efficiency is nearing the 80% goal.

Two Mechanical Harvesting Technologies Identified for Olive

Trunk shaker and canopy-contact harvesters utilized in other cropping systems have been modified for use on olive with minimal tree and fruit damage. Trunk shaker technology may be more applicable to olive trees with a smooth trunk, upright growth habit, and short scaffolds, whereas canopy-contact harvesters may be better suited for hedgerow plantings managed with mechanical pruning. Evaluations conducted by UC researchers have demonstrated at least 75% fruit removal efficiency by both harvester types, and sensory and consumer panels are unable to distinguish between hand-harvested and mechanically-harvested fruit.

Tree Shaker

A 2012 non-experimental evaluation of the Erick Nielsen Enterprises Inc. olive trunk shaker demonstrated an approximate 77.5% harvest efficiency in a mature, 180 tree/acre 'Manzanillo' block. Over the two years preceding this evaluation, the block was adapted for mechanical harvest by hand-pruning limbs likely to interfere with the harvester and mechanically hedging to reduce tree size. When operating at consistent speed, the trunk shaker harvested approximately 3 ton/hr without adverse affect on fruit quality. Conservative estimates suggest the trunk shaker harvest costs approximately $200/ton as compared to 2012 hand harvest costs estimated at $400/ton.

Canopy-Contact Harvester

A prototype canopy contact harvester, designed for jatropha (biofuel crop), was assessed in 2011 and 2012 in a hedgerow planting comprised of mechanically- and hand-pruned plots. The canopy contact harvester averaged 77% fruit removal; however, statistical comparison with hand harvested plots was not possible, in part because hand-pruned trees damaged the machine. The canopy contact harvester required 2-3 minutes harvest time per tree, and may yet prove to be of value to the olive industry.

Orchard Adaptation Strategies Studied

Orchard adaptation strategies for mechanical harvest have targeted both traditional plantings and the innovation of new orchard designs better suited for mechanical harvest.

Implementation of Mechanical Pruning: In 2011 and 2012, a hedgerow planting (12 x 18 ft; 202 trees/acre) at Nickels Soil Lab (Arbuckle, CA) was utilized to compare yield in mechanically-pruned and hand-pruned plots. Mechanically-pruned plots produced over 1.1 ton/acre more cumulative yield than hand pruned plots for an estimated >$1300/acre boost in crop value. Similar results were observed when mechanical pruning was compared to hand pruning in a traditional orchard (13 x 26 ft; 139 trees/acre) in Tulare County between 2008 and 2012. In this system, trees were mechanically topped at 12 ft. and hedged annually on alternate sides 6 ft. from the trunk. No significant difference in cumulative yield was observed between mechanically pruned and hand pruned plots from 2008 to 2012.

Orchard Design Innovations: Bill Krueger, Farm Advisor Emeritus, Glenn County, established the innovative hedgerow planting (12 X 18 ft; 202 trees/acre) at Nickels Soil Lab in 2001, utilizing four training techniques: i) conventional; ii) free trained espalier, iii) espalier woven in wire trellis, iv) espalier tied to trellis. Based on 10 years of data, tree training had no affect on yield or crop value. This planting continues to be of service to the olive research community, having housed mechanical pruning and mechanical harvest trials in the 2011 and 2012 seasons.

Mutually Beneficial Economic Interest Fosters Cooperation

The successful development of a mechanical harvester has relied on cooperation between university researchers and the two groups ultimately benefiting from the technology: the commercial harvester industry and the grower industry. Funding supplied by the California Olive Committee, the olive grower supported Federal Marketing Order, supported synergistic efforts between UC Davis Departments of Plant Science[1], Biological and Agricultural Engineering[2], Food Science and Technology[3], Agricultural Economics[4], and UC Cooperative Extension[5], University of Cordoba, Spain[6], and the harvester, grower[8], and processor industries[9].

Collaborative Team of Researchers and Cooperators:

L. Ferguson[1], J. Miles[2] and U. Rosa[2], J-X. Guinard[3], K. Klonsky[4], W.H. Krueger[5], E.J. Fichtner[5], N. O'Connell[5], P.M. Vossen[5] S.C. Garcia[6], Erick Nielsen Enterprises Inc.[7], Dave Smith Engineering[7], Gold Country Hydraulics & Hose Inc[7], Rocky Hill Ranch[8], Burreson Orchards[8], and Bell Carter Foods Inc[9] and Musco Family Olive Company[9].

Olive Tree Phenology: The relationship of fruit load to vegetative growth and return bloom

Elizabeth Fichtner, UCCE Farm Advisor Tulare Co. and
Carol Lovatt, Professor of Plant Physiology, Botany and Plant Sciences, UC-Riverside.

The first step in researching and developing strategies for mitigating alternate bearing (AB) in 'Manzanillo' table olive is to model the tree phenology with respect to the alternating 'ON' (high yield) and 'OFF' (low yield) cycles. In olive, the vegetative growth in one year produces the nodes bearing potential floral buds in the second year. Fruit load suppresses vegetative growth and return bloom; however, the mechanism underlying this relationship is unknown.

Hypothesized mechanisms (or combinations thereof) include:
1) Fruit inhibit vegetative growth, resulting in fewer nodes with the potential to flower and bear fruit.
2) Fruit inhibit floral development and/or spring bud break, reducing the number of inflorescences at return bloom.
3) Fruit reduce the number of perfect flowers in return bloom, resulting in fewer flowers with the ability to bear fruit.

Fruit load and inhibition of vegetative growth

<u>*Relationship of fruit load to vegetative growth*</u>. Olives are borne on one-year-old shoots; consequently shoot growth will be depressed during the year of a heavy crop, resulting in lack of fruitful shoots the following year (Sibbett, 2000). Working in both commercial orchards and at the Lindcove Research and Extension Center, our research team has similarly modeled this relationship in 'Manzanillo' olives in Tulare County. We assessed the influence of fruit on vegetative growth on 'ON' trees in comparison to 'OFF' trees, where 'ON' refers to trees with a heavy crop load, and 'OFF' refers to trees with a low or negligible crop load. Additionally, within 'ON' trees, we assessed vegetative growth on shoots bearing fruit and shoots not bearing fruit. The results of our study demonstrate the inhibitory effect of fruit on vegetative growth at both a tree and shoot level (Table 1). For example, between July 2012 and September 2012, an average of 3.3 nodes per shoot were produced on 'OFF' trees, whereas, non-bearing and bearing shoots on 'ON' trees produced an average of 0.7 and 0.6 nodes per shoot, respectively (Table 1).

Table 1. Vegetative growth represented by the cumulative number of nodes per shoot produced between July 2012 and the stated month.

Tree Status 2012	**Shoot Status**	# Nodes July '12	# Nodes July-Aug '12	# Nodes July-Sept '12	# Nodes July-Oct '12	# Nodes July-Feb '13	# Nodes July-April '13
OFF Control	No Fruit	2.2 a	2.9 a	3.3 a	3.3 a	3.6 a	5.0 a
ON Control	No Fruit	0.6 b	0.7 b	0.7 b	0.7b	1.0 b	2.7 b
ON Control	Fruit	0.2 b	0.5 b	0.6 b	0.6 b	0.8 b	3.3 ab
P value		0.0019	0.0047	0.0058	0.0059	0.0053	0.0397

<u>*Seasonality of vegetative growth*</u>. As a precursor to developing chemical treatments (e.g. Plant growth regulator) to mitigate AB, we investigated the fluctuation of growth rate by season (Table 1). The results of our 2012 data collection indicate that vegetative shoot growth proceeds through September, but effectively ceases sometime between September and October. Minimal vegetative growth occurs during the winter months (i.e., October through February), but the vegetative growth rate accelerates in the late winter/early spring (February-April).

<u>*When does vegetative growth on 'ON' branches effectively 'catch up' to growth on 'OFF' branches?*</u> Our data suggest that vegetative growth rapidly accelerates on 'ON' shoots between February and April; by April no significant difference was observed in the number of nodes produced since the preceding July for bearing shoots

on 'ON' trees and 'OFF' trees. During the late winter/early spring, the fruit are no longer present to suppress vegetative growth, and formerly 'ON' shoots will effectively 'catch up' to the 'OFF' shoots. This late winter/early spring growth; however, will not produce inflorescences in the current year because they were formed after floral bud induction and development.

Fruit may inhibit floral bud break

Fruit inhibit return bloom in 'Manzanillo' olive (Table 2); however, it is yet unknown whether fruit only inhibit vegetative shoot growth, or also inhibit the formation of floral buds, or only inhibit the spring break of floral buds. Our research has documented the extent of fruit's suppression of return bloom, with inflorescence counts highest on 'OFF' trees, followed by non-bearing and bearing shoots on 'ON' trees. The combined whole-tree and localized shoot effect on inflorescence counts was observed on bearing shoots of 'ON' trees, as evidenced by statistically fewer inflorescences produced per shoot than non-bearing shoots on 'ON' trees (Table 2).

Table 2. Influence of tree and shoot status on inflorescence production.

Tree Status 2012	Shoot Status	Total Inflorescences per Shoot
'OFF' Control	No Fruit	9.3 a
'ON' Control	No Fruit	2.8 b
'ON' Control	Fruit	0.6 c
P value		0.0001

Our current data suggests that, in addition to the loss of potential inflorescences due to the inhibition of summer vegetative shoot growth, at least a portion of fruit-mediated reduction of return bloom is related to reduced spring bud break. Floral buds of 'Manzanillo' olive are formed in late summer or early fall, but branch injections with the cytokinin plant growth regulators 6-benzyladenine or a proprietary cytokinin in February 2012 resulted in over 60% increase in number of inflorescences on non-bearing shoots on 'ON' trees at bloom in 2012, consistent with overcoming bud dormancy of viable floral buds. Our data, therefore, demonstrate that a portion of reduced return bloom is related to inhibition of floral bud break.

…a portion of reduced return bloom is related to inhibition of floral bud break …

Fruit reduce the percent of perfect flowers at return bloom

Olives are andromonoeceous, meaning they produce both perfect flowers, containing male reproductive structure (stamens) and female (pistil) structures, and staminate flowers (containing only male parts). Staminate flowers are unable to bear fruit. During floral bud development, all buds contain pistils and stamens; however, pistil abortion approximately 8-10 weeks prior to bloom results in a reduction in the proportion of perfect flowers formed. The results of our research provide evidence that the bearing status of a shoot affects the percent of perfect flowers formed (Table 3). The results suggest that failure of the pistil to develop and form a perfect flower is strongly associated with the presence of fruit set on a shoot and not due to crop load since the percentage of perfect flowers on nonbearing shoots of 'ON' trees is equal to that of nonbearing shoots on 'OFF' trees, but dramatically reduced for bearing shoots on 'ON' trees. Consequently, shoots bearing fruit in year one will have fewer perfect flowers in year two.

… shoots bearing fruit in year one will have fewer perfect flowers in year two.

Table 3. The bearing status of trees and/or shoots influences the characteristics of return bloom.						
Treatment	**Shoot Status**	**Total Inflorescences per Shoot**	**Total Flowers per Shoot**	**Flowers/ Inflorescence**	**Total Pistilate Flowers per Shoot**	**% Perfect Flowers**
'OFF' Control	No Fruit	9.2 a	24.6 a	3.3 a	21.4 a	87
'ON' Control	No Fruit	0.2 b	1.6 b	1.6 a	1.4 b	88
'ON' Control	Fruit	0.4 b	0.0 b	0.0 a	0.0 b	0
P-Value		≤0.0009	≤0.0001	≤0.1745	≤0.0001	

Summary

As a result of collaborative work between UC Cooperative Extension and UC Riverside, we have enhanced the understanding of the phenology of 'Manzanillo' olive with respect to alternate bearing and the cycling of 'ON' and 'OFF' crops. This phenological modeling illustrates the influence of fruit on vegetative growth and the seasonality of vegetative growth. The work additionally addresses the influence of fruit on both return bloom and the number of perfect flowers produced. Last, our work on mitigation of AB in olive provided evidence that fruit reduce floral intensity by inhibiting spring bud break and that floral buds had developed.

Further studies are underway to elucidate the timing of flower bud development. We are currently investigating whether fruit inhibit floral development on bearing shoots of 'ON' trees by examining the expression of key genes that regulate floral development. Enhanced understanding of the phenology of 'Manzanillo' olive will allow for precision timing of practices designed to mitigate AB and minimize the annual fluctuations in crop load and industry inventory.

Acknowledgements

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Literature Cited

Sibbett, S. 2000. Alternate bearing in olive trees. California Olive Oil News. Vol. 3, Issue 12.

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