Developing Mechanical Harvesting for California Black Ripe Processed Table Olives: 2007-2010: Year 4/4 Interim Report

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Industry Cooperators

Ranch Cooperators	Harvester Cooperators	Processor Cooperators
Rocky Hill Ranch	DSE	Bell Carter Olives
Erick Nielsen Ranch	Erick Nielsen Inc.	Musco Family Olive Company

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PROJECT SUMMARY AND MAJOR CONCLUSIONS

This is the interim report for the fourth and final year of a project to develop economically feasible mechanical harvesting for California black ripe 'Manzanillo' table olives. Harvests have been completed. The engineering analysis of the operating parameters of each harvesting technology evaluated will be completed before the presentation of the final 2011 proposal presentation (16 February 2011). The sensory and consumer evaluations of the harvested fruit will be completed in spring and summer of 2011 and a full final report submitted by September 31, 2011.

The objectives of this project were defined by, in order, the most limiting factors to mechanical harvesting; 1) fruit damage; 2) effective fruit removal technology; and 3) developing an economically viable harvester and defining its operating parameters. At this point, fruit damage has largely been eliminated and both canopy contact and trunk shaking technologies have been demonstrated to be effective fruit removal technologies. However, in practice both harvesting technologies are limited by tree canopy shape and by their respective platforms.

To achieve these objectives we focused on evaluating canopy contact and trunk shaking harvest technologies, evaluating the processed product, preparing trees with young orchard development and mature tree mechanical pruning, and evaluating potential abscission agents.

The major cumulative research results thus far are: 1) Canopy contact and trunk shaking harvesting technology can produce processed 'Manzanillo' olives that neither trained sensory or consumer panels could distinguish**;** 2) Canopy contact harvesting is over 90% efficient if the olives are accessible; 3) Mechanically hedged and topped trees were harvested significantly more efficiently by a canopy contact head than hand pruned control trees in 2010; 4) Ten year old 'Manzanillo' orchards trained with or without a trellis, in a 12x18 foot spacing, into a 12 foot tall, 6 foot wide tree skirted at 3 feet had statistically the same yields as conventionally trained trees**;** 5) Sixteen year old 'Manzanillo' trees spaced 13 X 26 feet and mechanically hedged 6 feet from the trunk on one side in 2008, the other side in 2009, and topped 12 feet and skirted at 3 feet both years, and not mechanically pruned in 2010, had significantly lower yields in 2010 than hand pruned control trees, but not in 2008 and 2009; and 6) Evaluating the most viable potential abscission compounds produced insignificant and inconsistent results.

T**he overall conclusion** that can be synthesized from these results is that both canopy contact and trunk shaking harvesting technologies can achieve economically viable mechanical harvesting if the fruit is accessible to the machine. To demonstrate this, the canopy contact and trunk shaking technologies must be improved through engineering, tested on effective platforms and evaluated on properly trained trees. This approach will require an engineer to head the project with cooperating horticulturists to prepare the trees in coordination with the engineer.

2010 RESEARCH RESULTS

In 2010 this project simultaneously focused on two major objectives: **1) improving the harvesting technology;** and **2) increasing harvester efficiency by adapting current orchards with mechanical pruning and developing new hedgerow orchards**. The preliminary data below gives the final efficiencies of two canopy contact heads, one in mechanically hedged and topped trees, and one trunk shaker.

The 49 – 62% final efficiency for the Canopy Contact I head was expected (**Table 1**). This was the range of harvest efficiencies demonstrated by this head in 2008 and no significant engineering improvements have been added to this head since then. In 2008, we concluded that we had learned as much as possible from this head in this configuration and should not evaluate it again unless the head had been improved. Our 2010 data confirms this; the overall efficiency of the head has not improved, remaining below 64%.

The Canopy Contact I head was 7.08% more efficient in mechanically hedged and topped trees having a statistically significant 57.35% average final efficiency in mechanically pruned rows versus 50.27% efficiency in conventionally pruned rows. However, these mechanically topped and hedged trees also had a statistically significant 19.4% lower yield per acre. As harvesting technology efficiency improves, we can determine if the significant decrease in harvest cost will offset the gross return losses generated by mechanical topping and hedging to

Table 1. Comparison of harvester technology final removal efficiency.

Harvest Technology	Final Removal Efficiency Range (%)	Efficiency Average (%)	Hand Pruned Trees *	Mechanically Hedged and Topped Trees**
Canopy Contact I	49 – 62%	55%	***57% a #***	***50% b #***
Canopy Contact II+	41 – 62%	49%		
Trunk Shaking +	31 – 49%	43%		

- *3, 83 tree rows: Rocky Hill Ranch, Tulare County (Average FRF = 0.586 kg)
- ** 6, 83 tree rows, Rocky Hill Ranch, Tulare County (Average FRF = 0.597 kg)
- # Values within ***these two cells*** are significantly different per T-test @ $p \leq 0.0001$
- + 3, 8 tree sets in hedgerow orchard: Nickels Soils Estate, Colusa County (Average FRF = 0.657 kg)

produce an equal or greater net return. Our results, and observations, strongly indicate the hedgerow configuration generated by the annual 12 foot topping, every other or third year mechanical hedging 6 feet from the trunk, and 4 foot skirting will be necessary to produce the flat "wall" of hanging olive shoots that make the fruit most accessible to the canopy contact head.

The preliminary 2010 data (**Table 2)** confirms the 2008 data for fruit quality. Both canopy contact heads and trunk shaking can produce a high percentage of cannable olives with low cull percentages equal to those of hand-harvested controls (HHC). The percentage of culls is a better method of evaluating harvest technology effects on fruit quality than the total adjusted price per ton as the latter can be strongly affected by fruit size percentages. The four cells on the far right of **Table 2** with values in ***bold italics*** highlight that there is a significant difference in cull percentages between the hand and machine harvested fruit between the two processors; indicated by A and B before the value in the table cells.

Now that both canopy contact heads and trunk shaking harvesting technologies can produce cannable olives with low cull percentages, the major emphasis should be on improving the harvesting technologies. The primary way of doing this is engineering. These two harvesting technologies need to be developed into effective harvesters that can maximize the efficiencies of the harvesting technology. The secondary method of improving the efficiency of these harvesters should be to improve mature tree pruning and young tree training.

Therefore the next step in this harvesting project should focus primarily on engineering and be directed by an engineer, preferably in cooperation with a commercial harvester fabricator. The horticultural improvements in tree pruning and training should be done in close cooperation

Table 2. Effect of harvesting technology on % canning fruit and culls.

Harvester	% Canning*	% Canning* HHC	% Culls*+	% Culls*+ HHC
Canopy Contact I**	A: 95% B: 85%	A: 95% B: 92%	***A: 0.98% b*** ***B: 4.56% a***	***A: 0.81% b*** ***B: 0.88%b***
Canopy Contact II#	A: 93%	A: 94%	A: 0.71% B: 6.91%	A: 1.45% B. 0.66%
Trunk Shaker#	A: 95.6%	A: 87%	A: 0.69% B: 2.91%	A: 0.93% B: 2.00%

- *Olives were delivered to two processors on the same day
- **Replicated trial of 9 mechanically harvested and 12 HHC, 83 tree, rows; Rocky Hill Orchards, Tulare County.
- # 3, 8 tree, replications for each harvesting technology; Nickels Estate, Colusa County

- + Values in **two highlighted cells** followed by different letters (a,b) are significantly different at p = ≤ 0,0001.

with the PI engineer, based on what was learned through observations in 2010, and interactively during the harvesting evaluations. Effects on long-term tree health, primarily the effects mechanical harvesting on olive knot, can also be evaluated within this project.

If the sensory and consumer testing of 2010 fruit is consistent with the results obtained in 2008 (i.e., neither sensory or consumer panels could determine the difference between hand and mechanically harvested olives), then processed fruit sensory and consumer evaluations should be unnecessary in future trials.

In conclusion, this four-year project has successfully achieved some of its major objectives. First, the primary limiting factor to mechanical harvesting, final processed fruit quality, has been eliminated. Second, the best two potential harvesting technologies, canopy contact heads and trunk shakers have been identified and refined. For the latter, trunk shakers, the problem of trunk damage has also been eliminated. Third, how to improve harvesting efficiency through tree training and mechanical pruning, and how this will affect net return is being determined.

What is now needed is a stronger effort directed towards engineering improvement of the harvesting technology, including an effective harvesting platform, and a closer coordination of the engineering with preharvest and harvest season tree training and pruning. As a secondary objective, the long-term effects of mechanical pruning and harvesting can be coordinated with the already submitted olive knot proposal. Therefore an agricultural engineer, cooperating with the UCCE Specialists, and Tulare and Glenn county Farm Advisors, should direct this next stage of developing mechanical harvesting for California Black Ripe table olives. Final harvester development would probably be accelerated if the olive fabrication industry could be involved in developing the final harvester that incorporated the picking technologies we have developed.