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Mechanical harvester efficiency and damage evaluations

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Introduction and scope

A trial to determine the effects four different combinations of abscission compounds on the fruit removal and efficiency of mechanical harvesting was to be harvested at Lindcove Field Station (LFS) October 18th, 2006. However, pull testing prior to the mechanical harvesting demonstrated no significant difference in pull strength among the abscission treatments or between the treatments and the control treatment. Therefore this trial was converted to a trial examining the mechanical harvester's percentage fruit removal and percentage efficiency, effects on fruit damage, and effects on fruit processing quality. With most mechanical harvesting trials it is preferable to do entire row replications so the machine can operate as close to commercial practices as possible. However, this was an opportunity to evaluate the machine in addition to the more detailed analysis conducted by Dr. Rosa in the adjacent rows.

The objective of this trial was to determine the percentage, and location of tree's fruit removed by the mechanical harvester, lost to the ground during harvesting, and left on the tree. A second objective was to determine the types and frequency of damage sustained by these different percentages of fruit. A third objective, still in progress, was the effect of the harvester on table olive processing quality.

The long-term goal of this project is to develop economically feasible mechanical harvesting for table olives.

Conclusions

1. The current picking head harvester operated at 180 cpm and 1.25 mph removed, by weight, an average of 65% of the fruit from 15 unprepared but well pruned trees.
2. The final efficiency of the harvester was 54% due to losses from fruit either not caught in the catch frame or lost from the catch frame.
3. Location of the fruit on the tree greatly determined the mechanical harvester's removal efficiency. Fruit on the canopy facing the row middle was removed with 88-98% efficiency. Fruit on the canopy between trees was removed with 48-54% efficiency. A further 10-19% (by weight) was found on the ground, either having fallen there after being shaken off or having dropped out of the catch frame.
4. Before processing the mechanically harvested fruits sustained two types of damage; bruising and mechanical damage. Mechanically harvested fruit sustained an average of 45% bruising and 40 % mechanical damage. Fruit hand harvested from the trees after mechanical harvesting sustained 34% bruising and 12% mechanical damage. In contrast, hand harvested fruit from trees not previously

mechanically harvested sustained an average of 17% bruising and 6% mechanical damage.

5. The final step of this experiment will be to compare the processed fruit from mechanical harveste, hand harvest after mechanical harvest, and a control hand harvest treatment; this will be done in early March of 2007 after the fruit has been canned.
6. Additional work on the mechanical harvester must focus on how to increase fruit removal and final harvester efficiency, as well as how to decrease bruising and mechanical damage.

Materials and methods

<u>Lindcove Research and Extension Center trial: October 18 2006</u>

The mechanical harvesting trial was conducted on October 18, 2006 in a block of olive trees located on the north perimeter of the Lindcove Research and Extension Center, Exeter, CA. The purpose of this trial was as stated above. Within 2, N-S oriented rows, (6 and 7); the 15 best cropped trees were selected and divided into three blocks containing 5 trees each. As mentioned earlier these 5 different trees received a control and 4 different abscission treatments that produced no statistically significant results, nor were any trends detectable in the data. Therefore the mechanical harvesting data was treated as if the trees had not been treated with abscission chemicals.

Prior to mechanical harvesting 20 shoots in the tree were tagged. The tags were spaced evenly abut the tree at about the tree circumference at mid and upper canopy level. The number of fruit below these tags was counted prior to mechanical harvesting. The fruit below the tags was recounted after mechanical harvesting. The objective was to determine where in the canopy fruit removal was best.

Prior to mechanical harvesting tarps were spread under the trees and the bottom of the canopy was hand pruned to a height of 1m above the ground. The mechanical harvester was driven down one side of each row at 1.25 mph. After each treatment tree the harvester was stopped, the catch frame emptied into a field bin, weighed and kept separate. Fruit on the tarp was collected, weighed and also kept separate. Once one row side was completed the harvester was driven down the opposite row side and fruit collected in a similar manner. After all the trees had been harvested and the fruit collected from the tarps, the remaining fruit on the tree was hand harvested.

The mechanically harvested and hand harvested fruit from both sides of the tree were pooled within their harvesting method; mechanical or hand harvested, and mixed. A 20 pound sample of each harvest method was taken to the Musco grading station in Strathmore. The samples were graded and then each was divided into 2, 8 pound, and one, 4 pound, samples. The 8 pound samples we delivered to and Musco and Bell Carter for processing as black ripe table olives and the 2 pound sample sent to Dr. Carlos

Crisosto's lab for fruit quality evaluations. Dr. Crisosto's evaluations will be compared with the quality of the processed olives when cut in March, 2007.

<u>Fruit Harvesting and Quality Process</u>

<u>15 trees</u>

<u>Mechanical harvest followed by hand harvest</u>

<u>20 pound sample of hand and mechanical harvest collected and mixed</u>

<u>Graded @ Musco grading station</u>

<u>8 (Musco), 8 (Bell Carter) and 4 (Crisosto) pound graded, machine and hand harvested samples delivered to processors and Crisosto lab</u>

<u>Olive cutting and correlation with Crisosto grade in March 2007</u>

Results and discussion:

<u>Percentage (by weight) removal and efficiency of the mechanical harvester:</u>

<u>Harvester % removal was calculated as follows:</u>

MP = mechanically picked fruit collected in harvester bin

GP = fruit picked up off the ground after mechanical harvesting

HP = fruit hand harvested from tree after mechanical harvest

$$\frac{(MP) + (GP)}{(MP + GP + HP)}$$

$$=$$

% removal by harvester

Harvester % efficiency was calculated as follows:

$$\frac{MP}{(MP + GP + HP)} = \text{Harvester \% efficiency}$$

Percentage Removal by harvester	Percent Efficiency of harvester
Range: 56.89% - 74.69%	Range: 47.57% - 61.39%
Average: 67.17% (+/- 7.3)	Average: 53.85% (+/- 6.1)

Table1. This table shows the average % (by weight) calculated harvester fruit removal and calculated harvester efficiency on 15 trees. These values were the averages of 5, 3 tree, replications.

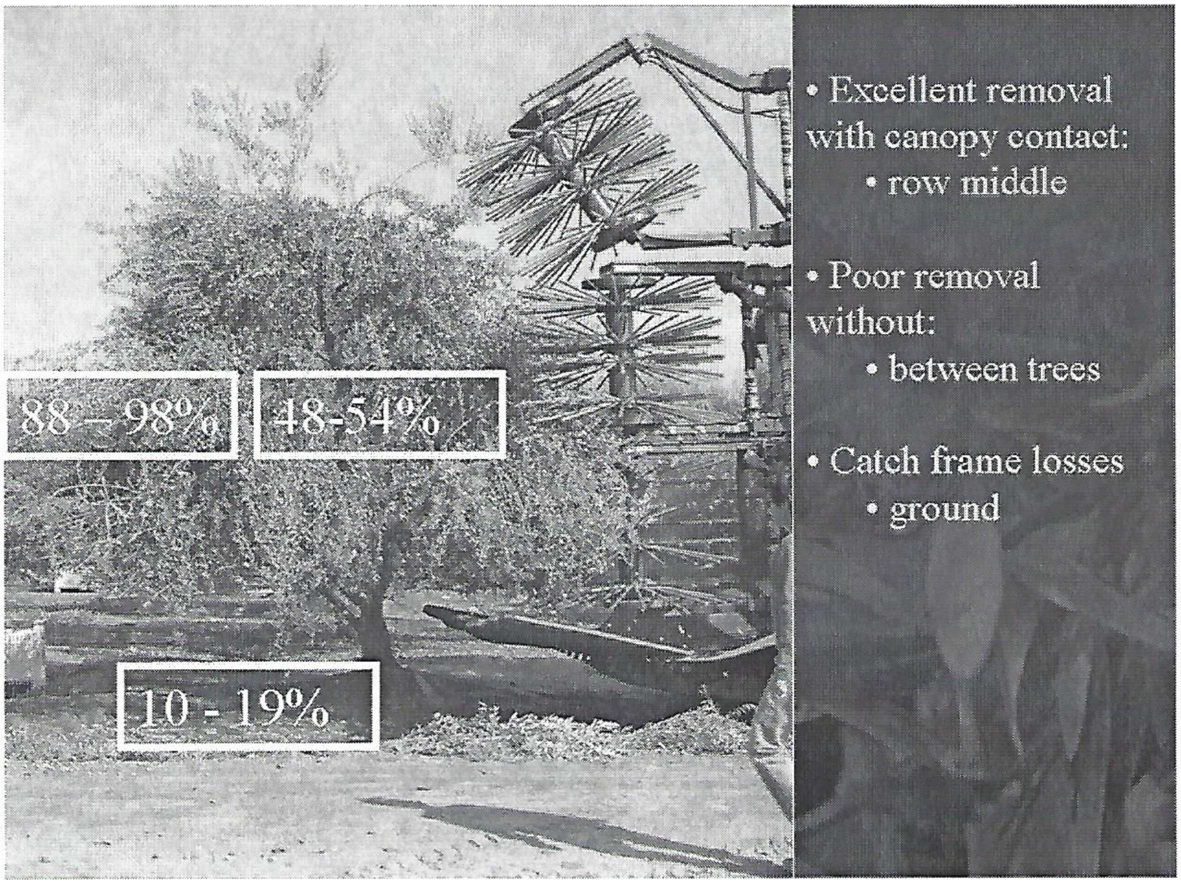
This picking head harvester, operated at 1.25 mph and 180 cpm had a final efficiency of approximately 54%. To improve the final efficiency of the harvester the fruit will need to be made more accessible, and detach with less force. We should focus our research on canopy pruning and developing an abscission agent.

Percentage removal by fruit location:

Where the fruit was on the tree had a significant difference on the % removal. This data was generated by a number count of fruit on tagged shots before and after mechanical harvesting and a calculated final percentage removal.

Figure 1 demonstrates the range of % fruit removal on different portions of the canopy. Where the picking head made contact with the canopy it removed 88-98% of the olives. Between in the trees, in-row, only 48-54% of the fruit was removed. This reinforces the above % fruit removal data that indicates the fruit need to be more accessible to the picking head to be removed.

Figure1. Percentage fruit removal by canopy location (by fruit count on tags) and ground fruit after mechanical harvesting (by weight).



Effect of mechanical harvesting on fruit quality

Three types of fruit samples were taken from the mechanically harvested trees; mechanically harvested fruit, fruit hand harvested from the trees after mechanical harvesting, and hand harvested fruit from control trees that had not been mechanically harvested. Fruit that dropped on the ground after mechanical harvesting was not tested for damage on the theory that it would not be collected during commercial mechanical harvesting. Again there were three replications of five trees each. Damage was rated as bruising (skin not broken) and mechanical (skin broken). The % damage ranges and ranges and average values are given in Table 2.

Harvest Method	Bruising: % range	Bruising: % Average	Mechanical: % range	Mechanical: % average
Mechanical Harvest	40 – 47%	45% (+/- 2.1	36 – 49%	40% (+/- 3.2)
Hand after Mechanical	22 – 51%	34% (+/- 3.7)	9 – 13%	12% (+/-1.4)
Hand Harvest Control	8 – 31%	17% (+/- 5.2)	1 – 9%	6% (+/- 2.1)

Table 2. Percentages of damage by bruising (skin not broken) and mechanical (skin broken) damage of mechanically harvested fruit, fruit hand harvested from a tree previously mechanically harvested and from a hand harvested control tree.

The above data suggests that the mechanical harvester produces almost as much bruising on the fruit it left in the tree as it does on the fruit it harvests into the catch frame; 34% of the fruit left in the tree was bruised versus 45% of the fruit in the catch frame. However, the machine does not appear to mechanically damage the fruit left in the tree as much as it damages the fruit harvested into the catch frame; only 12% of the fruit left in the tree was mechanically damaged versus 40% of the fruit in the catch frame. This strongly suggests ricocheting down through the canopy and the harvester head, and activity in the catch frame, is producing most of the mechanical damage to mechanically harvested fruit. Dr. Rosa's more detailed analysis should demonstrate whether or not this is true.

This data was produced by Dr. Crisosto's laboratory evaluations. Matching sets of fruit were sent to Bell carter and Musco olives for two months of brine storage and subsequent canning. The objective was to duplicate commercial black ripe table olive processing. These canned samples will be evaluated together by Dr. Crisosto and by the two processors together. At that time a correlation of the damage observed postharvest with processed table olive quality will be done by Dr. Crisosto. This should be in early March, 2007.

Summary

This experiment has demonstrated the current picking head harvester has the potential to successfully remove a high percentage of the fruit if it is accessible to the picking head. The more detailed analysis of Dr. Rosa may shed more light on how to increase the efficiency of the machine. However, these results strongly suggest pruning current orchards to a hedgerow will improve picking head harvester efficiency.

The fruit damage sustained, as determined in postharvest fruit evaluations, appears too high. This may or may not be confirmed when the processed fruit is evaluated in March, 2007. However, at this point it does appear that decreasing fruit removal force will be the major way to increase harvester efficiency and decrease fruit damage.

Acknowledgements

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