HISTORY AND STATUS OF MACHINE OLIVE HARVEST IN CALIFORNIA

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Introduction

California industry facts

- Over 99% of the olives grown in the United States are grown in California. There is a small percentage of the acreage in Arizona. Most of the acreage is grown in the interior valleys of California.

- Approximately ~1,000 growers farm ~33,000 bearing acres (13,200 ha) of olives in California.

- California is primarily a table olive industry producing the "California black ripe" table olive. This is a product unique to California as it is picked immature (green) and made black by oxidation in a caustic soda cure that removes the bitterness prior to brining. Conversely, Mediterranean style olives are picked fully mature and processed without lye.

- A small, but active olive oil industry, less than 1,500 ac (600 ha), exists, largely in the coastal areas.

- The California table olive crop ranges in size from 70,000 to 140,000 short tons.

- California grows almost 11.2 % of the total world production of table olives and 0.1% of the olive oil.

- Over 95% of the olives in California are hand harvested by, largely a Mexican workforce. Mechanical harvesters are being tested and built for commercial table olive harvest but machines are expensive with the technology still being developed.

- Operating costs required to produce an acre of table olives (5 short tons) is approximately USD$2,076 (USD$5,190/ha), including hand harvest costs of USD$ 1,300 (USD$3,250/ha) or ~63% of operating costs.

Reducing olive harvest cost has been the highest priority of the California olive industry. This paper provides the reader with both the history and current status of mechanizing the table olive harvest in California.

History of mechanized olive harvest in California

Research, mechanizing the fruit and nut harvest in California, was begun by Fairbank in 1946 testing various shakers. In 1949, the leadership within the California olive industry met with University of California agricultural engineers to emphasize the need to mechanize their olive harvest; hand harvest costs were 50% - 70% of the total costs to produce them. Realizing limitations of shaking olives, other ideas included: create some environmental condition to promote fruit removal; develop a fruit-loosening chemical; consider a rubber fingered vibrating rake; and use of a sudden intermediate force (black powder, water jet etc.) to snap fruits from the tree. The consensus was to develop a rubber fingered rake, mount it on a 2m handle, and provide an aide (e.g. platform) so workers could cover the tree easily. However, to be economical then, such a device would have to double the output of one hand picker. It did not appear that such a device would be economic.

In the 1950's, others, McKillop, Perry, Shultis, Hartmann, and Lamouria, extensively studied mechanical shaking and largely developed the technology for many fruit and nut crops. However, during these studies, it became obvious that existing shaker technology could not be translated to olives; tree injury and poor removal due to the olive's "willowy" growth habit were problems. By 1952, sufficient progress had been made to stimulate a long-range project on olive harvest mechanization. With the University of California's departments of Agricultural Engineering and Pomology cooperating. A number of fruit removal techniques were surveyed: air blasts, combing, explosives, boom and cable shakers, inertia shakers, knockers, water jets, and picker positioning aides. All of these had one or more of the following shortcomings: poor fruit removal, excessive tree damage, reduced fruit quality.

Mechanical tree shakers showed the most promise but processors were concerned about the fruit quality with shaking. To attain more satisfactory results, research, sponsored by the olive industry in the late '50's and '60's focused on: 1) fundamentals of olive tree shaking; 2) fruit collection devices; 3) fruit injury; 4) use of chemicals to induce fruit loosening; 5) modification of pruning techniques; and 6) development of shaking equipment specifically adapted to olive trees. Here's what was found.

Fundamentals of olive tree shaking:

Fruit detachment factors: The ratio of fruit removal force to fruit weight (F/W) is strong in olives; values range from 100 – 200 (30 - 40 for prunes). Thus, larger/heavier fruit are easier to remove than smaller ones.. Vibration intensity needs to be about double that indicated by F/W.

Fruit removal percentages: To attain 90% removal either a short stroke (~ 2.5 cm) and high frequency (2500 cycles per minute) or long stroke (10 cm) and low frequency (1000 cycles per minute) are required. Limb shaking is necessary.

Tree damage: Bark damage is related to clamp strength but limb breakage also occurs with long strokes and especially at low frequencies. Trees grafted while mature, will be especially susceptible to breakage.

Leaf drop: Excessive leaf drop reduces next season's bloom. High frequency shaking aggravates leaf drop.

Root injury: Root injury did not appear to occur from shaking. Heavy equipment working on wet ground may injure roots.

Fruit collection devices: A "wrap around" and hand-carried frame were first tested. Both devices had serious problems such as: interference with the shaker, poor fruit collection, excessive labor etc. A side-by-side catching frame also proved to be difficult to operate when maneuvering and attaching the shaker to the limbs. A "roll out" catcher seemed the most promising but shaker movement while attaching to limbs crushed olives was problematic.

Fruit injury: Injury occurs when olives hit shoots before detachment, impact branches as they fall through the tree, and as they contact the catching frame. Effects of vibration, duration of shake, and collection on fruit injury were determined.

Use of chemicals to induce fruit loosening: A loosening agent must: be inexpensive, leave no toxic residue, not cause excessive leaf loss, not interfere with flower formation the following year, not reduce fruit quality, and be active under a range of climatic conditions. Many materials were tested in the '60's (e.g. Maleic hydrazide, Ascorbic acid, Glycerine, Iodoacetic acid, Ethephon) but none were found that satisfied the above requirements.

Modification of pruning techniques: Trees best suited for shaking are open vase shaped with four to six vertically oriented scaffolds with no low hanging branches.

Development of shaking equipment specifically adapted to olive trees: The studies above led to development of an inertia limb shaker in 1955 built especially for olives – the "U.C. Olive Shaker". The shaker had high initial acceleration, operated at 1200 cycles per minute, and at strokes ranging from 15 cm to 11.25 cm. The clamp had a check valve to minimize clamp pressure and thus limb injury. Such a shaker was designed to remove 90% of the olives off of well-trained trees. The catcher was a roll out frame positioned below the shaker extending 1.5 m outside the "drip line" of the tree.

The shaker/catcher picked up to 30 trees per hour with up to 80% fruit removal, somewhat less than desired. Fruit quality for the black ripe process was similar to hand picked fruit but was inferior if the fruit were to be used green. Placing fruit into brine in the field mitigated fruit damage.

Conclusions: A highly successful mechanized harvest can only result from: 1) a properly designed machine, 2) healthy trees pruned for mechanized harvest with proper management, and 3) an effective loosening agent. No loosening agent had yet been found.

U.C. Shaker status: The "U.C. olive shaker" specifications developed from these studies were presented to California's shaker manufacturers. Shaker manufacturers did not accept the design and instead preferred to use their own technologies for olive shaking. As a result, the only olive growers to use conventional shakers were those one or two exceptionally large growers that couldn't get sufficient labor or several that had labor difficulties with the unions. Due to well-known problems of shaker harvest, i.e. poor fruit removal, fruit and tree damage, expense, and very slow operation, essentially all other acreage was hand picked.

Harvest aids: Within this time frame, various harvest aids have been tried in the table olive harvest. Tools such as variously powered vibrating hand rakes, elevated platforms etc. have been tried to reduce the cost of hand harvest. Invariably, such devices did not replace field workers and have only been used in very small blocks where attracting hand pickers was difficult.

1995

Mechanizing the table olive harvest in California was still the highest priority of the industry. In absence of a chemical loosening agent, shaking had not been effective and those very few that had to use the technique were dissatisfied with the result. Simply, the industry was frustrated with shaking; it did not appear to be a viable alternative to hand picking table olives.

In January 1995 the California Olive Committee (COC), who administers the federal marketing order for olives, called harvesting equipment manufacturers together to solicit novel ideas they would fund for harvesting table olives mechanically. The COC first funded AgRight Enterprises of Madera California who agreed to develop a prototype, vertical combing device patterned after their grape harvesting technology. They built and field-tested a harvester first equipped with one and subsequently two vertically arrayed, force balanced, radial shaking, picking heads that harvest in a vertical plane down the tree row. For most effective harvesting, a hedged face was recommended. The harvester was quite effective, picking every olive it touched at a rate of about one tree per minute. However several problems were apparent with these 1st models: e.g. inability to pick certain parts of the tree (e.g. the leading and trailing edges), mediocre catching technology resulting in fruit loss, interference with larger branches, and heavy weight etc. The next generation of AgRight machines included three picking heads with more "in-and-out" flexibility that did not require as extensive tree hedging. In addition, the catch frame was improved. Machine weight was still somewhat problematical. At the end of the '99 year, funding was stopped to allow commercial production of this technology and sale to the industry.

In ~1999 Korvan Industries of Lyndon, Washington, approached the COC with refinement of the AgRight technology based upon their experience with coffee harvesters. Financial support was also provided Korvan by the COC to develop an appropriate machine as they wound down financial support for the AgRight. The Korvan equipment utilized three vertical combing heads similar to the AgRight. However, the equipment was quite a bit lighter in weight than AgRight with about the same effectiveness. Lighter weight, however, resulted in more maintenance problems. In 2001 funding was withdrawn from Korvan to allow commercial production and sale of that equipment as well.

Current mechanical harvesting status

Currently in California, there are ~ 9 (including AgRight and Korvan) machines working in the commercial table olive harvest. Several custom harvesters own machines and charge growers; prices are variable. The technology is not yet "state-of-the-art". Issues such as fruit collection, tree pruning for best fruit removal, harvester weight, and mechanical soundness still remain and require improvement. However, most agree that the combing technology will survive. In fall of 2001, Korvan Industries projected 10 machines would be in the field for the 2002 table olive harvest.

Oil olives

A small but active olive oil industry is developing in California. For the most part, these are very small operations often only amounting to a tree row or two around a winegrape vineyard. Such farms will always be picked by hand or with a harvesting aid (e.g. hand-held vibrating rakes). However, several larger blocks have been dedicated to oil and are committed to machine harvest. Currently these operations are testing foreign equipment such as straddle tree (e.g. Gregoire) and tractor mounted harvesters (e.g. Verdegiglio). As trees in these larger operations mature and attain large size, machine harvesting will become more difficult. However, no data has been collected or analyzed to develop costs for mechanical harvest.

Summary

A mechanized olive harvest has been a high priority for California's table olive industry for more than 50 years. During this period of time, considerable research has been done developing the fundamentals for shaking/catching olives, designing appropriate machinery, investigating fruit loosening chemicals, and determining appropriately trained trees. The "U.C. shaker/catcher emerged from that work and did a reasonable job of harvesting table olives. That technology was never utilized by harvesting companies and their existing shaking technologies were, and still are unacceptable. Technology involving two vertically arrayed, force balanced, radial shaking, picking heads that harvest in a vertical plane down the tree row was developed and is in limited use in the table fruit industry. Considerable work still needs to be done to make this technology state of the art.