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A PROGRESS REPORT ON THE SHAKE HARVEST OF AVOCADOS

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The need for the avocado industry to develop a more efficient method of harvesting has been created by an uncertain labor supply, increased costs, unpredictable yield and price, and tall trees that are difficult to harvest.

The conventional method of harvesting avocados is by hand, using a clipper and bag (Figure 1). The fruit is held with one hand and the stem cut close to the fruit. Various types of equipment may be used to make the fruit out of reach from the ground more accessible to the picker. These include ladders, poles, and various self-propelled, one-man positioning machines (Figure 2). Fruit harvested with a clipper attached to a pole is cut with a long stem. Before placing fruit in a field box, the long stem must be reclipped to avoid damage to adjacent fruit.

The cost of harvest is dependent upon the yield, tree height, and type of equipment used. In general, the lower the yield and the taller the tree, the greater the harvesting cost. Costs range from 1 to 6 cents per pound.

A new approach to harvesting avocados is to mechanically remove the fruit by shaking. The result of this field trial is the first attempt to use shaking equipment for harvesting avocados. Commercial shake harvesting equipment is available and is presently used for harvesting almonds, apples, apricots, cherries, peaches, plums, prunes, and walnuts.

Orchard

The Bacon avocado orchard used for this field trial is located near Santa Paula in Ventura County. The trees were planted in 1959. The growth habit of the Bacon variety is slender and upright, often reaching the height of 30 feet or more. Structurally, depending upon early tree training, the tree may have a single trunk or 2 to 5 major scaffold branches rising from a point near the ground and growing parallel to one another. As the Bacon tree matures, the majority of fruit is produced in the upper half of the tree, thereby making hand harvest more difficult. Attempts to discourage top-fruiting and reduce harvest costs by severely topping the tree to lower the over-all height has resulted in drastically reduced yields.

Figure 1. Conventional handpicking of avocados using bag, ladder, and clipper.

Equipment

Three types of equipment were used in this test. Two were furnished by Orchard Machinery Corporation (OMC) of Yuba City, namely, a Shock-Wave trunk shaker mounted on a peach-catching frame (Figure 3), and a Mono Boom shaker positioner (Figure 4). The third, a limb shaker (Figure 5) was provided by the USDA, Agricultural Engineering Research Division at the University of California. Riverside. This shaker was originally developed by the University of California, Davis, for olive harvest trials and later modified at Riverside for citrus harvest tests. For this test, it was positioned with a forklift mast mounted on a turntable on a 1½ -ton truck.

Procedure

TRUNK SHAKER

Twenty-Three trees were harvested with the trunk shaker-catching frame combination, arid three trees with the trunk shaker Mono Boom unit.

Clamp height varied between the trunk shaker-catching frame and Mono Boom units. The catching frame design limited the highest shaker attachment point to about 20 inches above the ground. The Mono Boom unit had a more flexible shaker positioner

and was attached about 36 inches above the ground.

Fruit was collected with the catching frame and conveyed to standard avocado field boxes at the rear of the machine. For tests with the Mono Boom unit, only one side of the catching frame was used to allow access for shaking. Fruit on the other side was collected on 2-inch padding material covered with canvas.

The trunk shakers were operated with various unbalanced weight combinations which were selected by the manufacturer. Shaker frequency varied during the shaking cycle and ranged from 700 to 1500 cpm. Actual stroke at the clamp was between ½ and ¾ inch. Total shaking time varied from 45 to 120 seconds.

After the fruit was collected, it was classified as fruit with or without stems, and counted. Fruit with stems were then hand-clipped before placing them in field boxes for shipment to the packinghouse for processing.

Figure 2. Single-man picker positioner used as a labor aid for handpicking avocados.

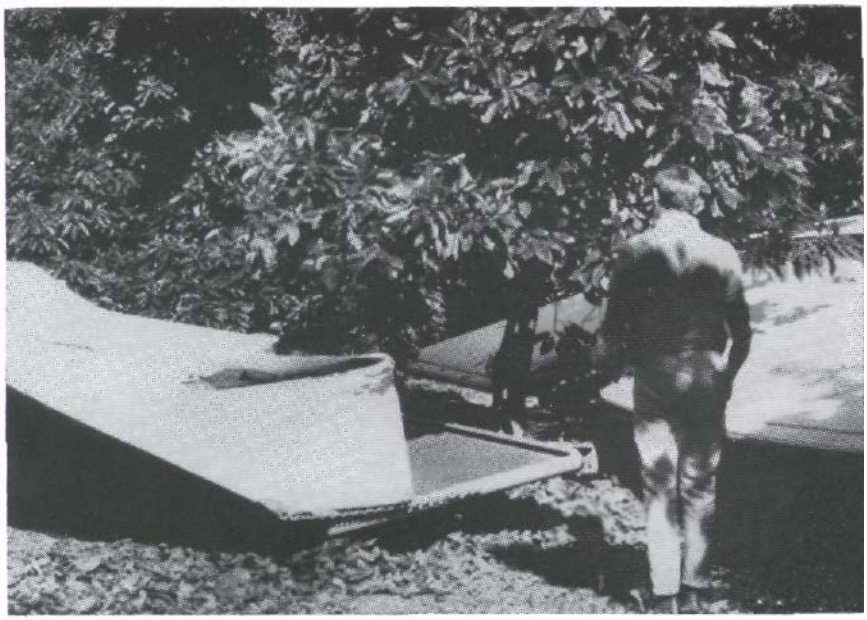

Figure 3. OMC's trunk shaker mounted on their peach catching frame.

Figure 4. OMC's Mono Boom shaker positioner and trunk shaker.

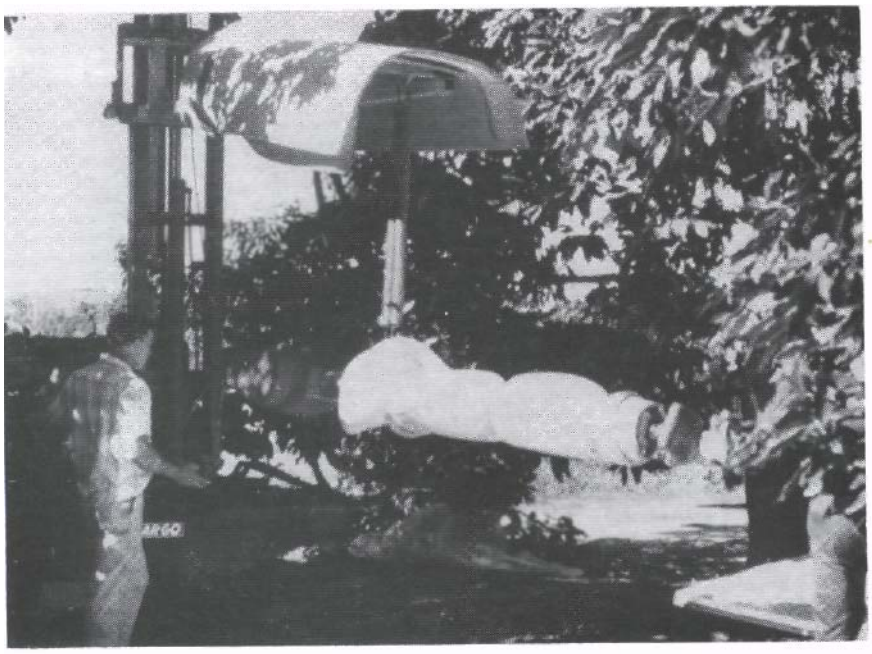

Figure 5. Limb shaker designed for experimental olive and citrus harvesting by U.C. Davis and USDA.

LIMB SHAKER

Twenty trees were harvested with the limb shaker. The shaker clamp was attached to the central leader of each tree, 5 to 7 feet above the ground.

Fruit was collected in the same manner as with the Mono Boom unit.

The inertia-type shaker had an internal stroke of 4½ inches. When operated between 350-550 cpm, the actual stroke at the shaker clamp ranged between 2 and 2½ inches. Shaking duration varied from a steady 5-second shake to short bursts of 1 to 3 seconds each.

Shaking Results

Fruit removal and detachment characteristics for each test are shown in the following table.

DETACHMENT CHARACTERISTICS

	Avg. Yield	*Removed*	*With Stem*	*Without Stem*
	Fruit	*Percent*	*Percent*	*Percent*
Trunk Shaker-Catching Frame, Avg. of 23 trees	405	67.6	91.1	8.9
Mono Boom-Trunk shaker, Avg. of 3 trees	267	90.8	91.9	8.1
Limb Shaker, Avg. of 20 trees	359	84.6	89.5	10.5

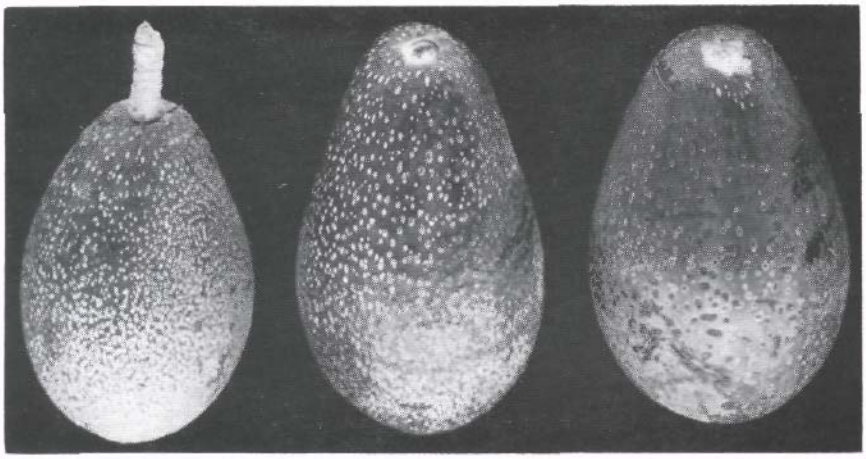

Figure 6. Types of fruit detachment by shaking-with stem, stemout, and pullout.

Differences in unbalanced weight combinations and clamp height probably accounted for the differences in removal between the two trunk shakers. Several short shakes of 1-3 seconds each were found most effective for removal with the limb shaker. Continuous shakes of 5 seconds or more did not increase fruit removal substantially while greatly increasing damage to leaves and branches, especially near the top of the tree.

Both shaking methods detached about 90 percent of the fruit with a stem (Figure 6). The remaining 10 percent were detached without a stem, with some actually having the flesh torn near the stem. Some fruit was split due to impacting on hard surfaces of the equipment after it was shaken off the tree. Splitting generally did not occur when the fruit fell on limbs or on the padded canvas.

Because the trees were in bloom and some blossoms shedding occurred during shaking, next year's crop will be evaluated to determine the effect of shaking on fruit set.

Approximately 80 field boxes from each harvest method were weighed and processed separately to determine effect on packout. The results of the packout are listed below.

PACKOUT

	1st Grade Percent	*2nd Grade Percent*	*Culls Percent*
Limb shaker	91.7	7.6	0.7
Trunk shaker	91.9	7.0	1.0
Hand picked	97.7	1.4	0.9

There was no significant difference in the packout between limb and trunk shaking. Most of the injured fruit was downgraded from first to second grade because of torn flesh where the stem was pulled from the fruit.

Post-Harvest Evaluation

Sample flats from each harvest method were shipped by refrigerated truck to Detroit, Michigan and Irvington, New Jersey markets. Fruit arrived in 6 to 12 days respectively.

On arrival at each location, 30 flats (1st grade—size 30) were carefully examined. Ten flats (300 fruit) from each harvest method were graded and fruit segregated by type of injury, if any. The results from grading the 10 flats are as follows:

INJURY EVALUATION

	Trunk Shaker	*Limb Shaker*	*Hand Harvested*
	Percent	*Percent*	*Percent*
Stemout[1]	4.7	4.0	0
Pullout[2]	0.3	1.0	1.7
Injured	1.7	1.7	0
Noninjured	93.3	93.3	98.3

1) Stem pulled free of flesh (See Figure 6)
2) Stem pulled flesh from fruit

Injured and stemless fruit were removed and placed in a separate flat. The rest of the flats were then refilled with uninjured fruit and set aside for ripening and observation.

From Detroit the following communication was received: "After ten days in the office, there was no difference in the appearance of the fruit except one with a stemout started to turn brown on the stem end. There was no internal bruising of any fruit on cutting. It all ripened the same and at the same time."

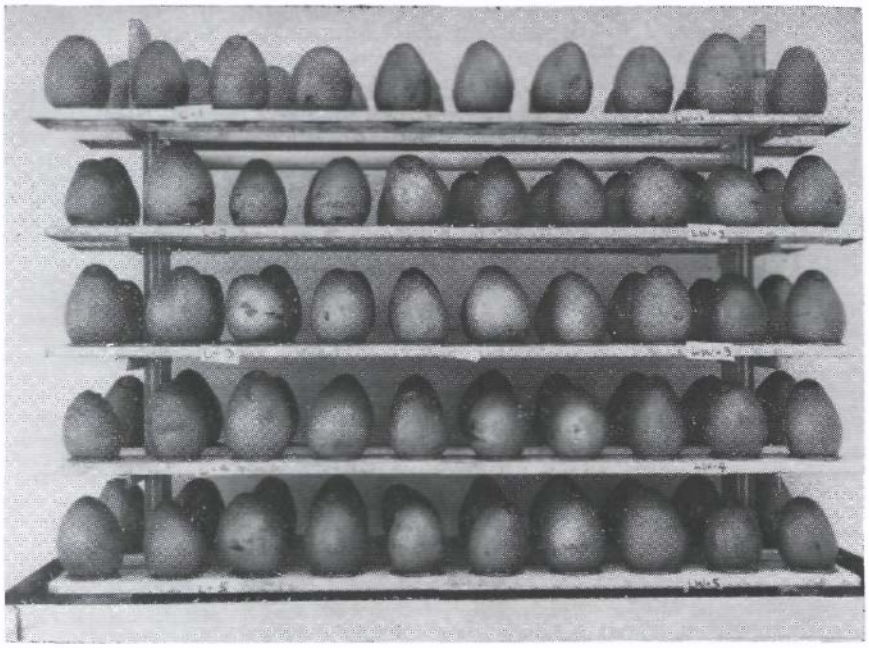

Figure 7. Sample of 25 shake harvested fruit after weight loss evaluation for 28 days at 45°F and 85% relative humidity.

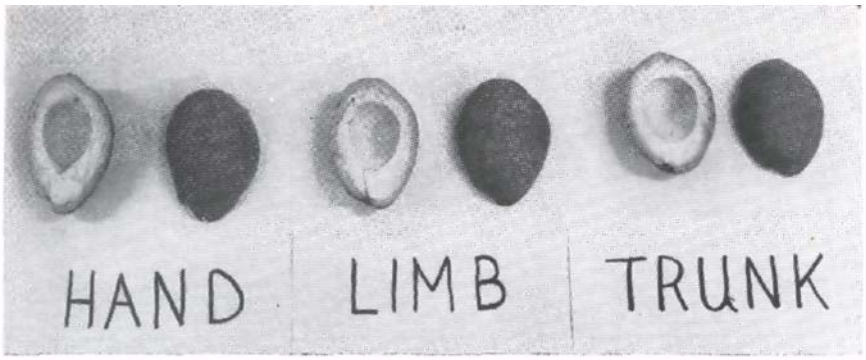

Figure 8. Typical peeled fruit after weight loss evaluation and 9 days of ripening at 60°F.

Other samples of fruit from each harvest method were used for weight loss, surface injury, and rate of ripening studies conducted at University of California, Riverside. These studies were made to determine if shaking caused fruit injury which would influence the rate of weight loss and ripening.

Weight losses were measured on samples of 25 fruit each (Figure 7). Two samples were used for each harvest method — hand, trunk shaker, and limb shaker. One sample for each harvest method was a control while the other sample had wax applied to the stem area.

Each sample was divided into five replications of five fruit each for weighing. Weights were recorded every day during the first week and every other day during the remaining period. The fruit was stored for a total of 28 days at 45 °F and 85 percent relative

humidity.

After the 28-day storage period, all samples were allowed to ripen for 9 days at 60°F. After ripening, the fruit was hand-peeled (Figure 8). Mechanical injuries were evaluated before and after peeling. Injuries visible before peeling but removed with the peel were considered small while injuries that showed decay or browning after peeling were classified as large. Results of the injury evaluation follow.

PEELED INJURY EVALUATION

	Percent with No Injury	*Percent with Small Injury*	*Percent with Large Injury*
Hand Harvested	82	18	0
Trunk Shaker	46	50	4
Limb Shaker	50	46	4

No bruising in the flesh or browning in the pit area was detected.

Shake-harvested fruit had a slightly higher weight loss than hand-picked fruit during the 28-day storage period. As an example, a 250 gm fruit, shake harvested, would lose about 2 gms more weight than a similar hand-picked fruit when stored for a similar period. Waxing the stem end of a similar sized shake harvested fruit reduced the weight loss for the storage period by 1.6 gms compared to an unwaxed shake harvested fruit.

Other Varieties Tested

In addition to the field trial with Bacon avocados, attempts were made to shake harvest two other varieties with the OMC Mono Boom.

In one orchard several large 20-year-old Hass trees were harvested. The results of shaking one tree follows, and is typical for the variety.

Fruit removed	210
Fruit remaining	54
Percent removed	79%
Percent with stems	11.5%
Percent without stems	88.5%

Hass without stems are often marketed as first grade fruit.

In another orchard several large 55-year-old Dickinson trees were harvested. Tree yield averaged 10 to 15 field boxes. Because of shading due to overcrowding of trees, all fruit was located in the top of the trees—30 to 40 feet above ground. From one tree, 4.5 field boxes or approximately 25 percent of the total crop were removed by shaking the trunk and two limbs. At the time the 1970 fruit was being harvested, fruit was set for 1971 and was already 3/4 to 3/4 in diameter. This field trial was suspended because hundreds of small immature fruit, representing next year's crop, were removed by shaking.

Conclusions

The avocado has generally been considered too delicate a fruit to be suited to mechanical harvesting. Based on the results of this field trial, trunk and limb shakers can be used successfully to remove 80-90 percent of the fruit from tall upright, single-crop varieties of avocados without excessive damage to the fruit or the tree. Varieties with mature and immature fruit both on the tree at harvest time cannot be mechanically harvested with present shaking equipment without excessive loss of immature fruit.

Shaking may reduce the packout of higher grades by about 6 percent, but the cull grade may not be substantially increased. Surface injury from cuts and abrasions is higher with shaking than hand picking, but flesh bruising or browning of the pit area is not a problem. Shakers and catching frames should be well padded to eliminate fruit splitting by impact.

Future Work

Further field trials are necessary to learn more about varietal differences, tree structure, optimum maturity, post-harvest response, and to further refine the mechanical equipment and techniques of shaking, including length and pattern of stroke, frequency and duration of the shake. Comparative costs of the various harvest methods need to be evaluated.

Acknowledgment

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