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MECHANIZING AVOCADO PICKING

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Large avocado trees on relatively flat land can be picked efficiently using a picker positioning machine to replace the ladder and pole picker.

In a trial of the Selma Tree Master in a Zutano orchard near Santa Barbara, the labor-saving benefits of the machine about equaled the added cost of machine operation. Other conveniences and efficiencies were observed. This trial conducted in the L. M. Cavaletto grove did not attempt to evaluate other orchard or slope conditions in which the machine might be used.

For years the use of poles and ladders have appeared to markedly slow down avocado picking rates, particularly in tall orchards. With the advent of a number of tree working machines, the possibility of mechanizing avocado picking increased. In 1964 the Cavalettos bought their first Selma machine; the next year they purchased another; both for use in their own groves. Their experience appeared to be favorable, but they wanted to know the details, so they invited the University and Calavo to cooperate in the trial being reported.

The Selma Tree Master is a picker-maneuvered, straight down the row machine, with an 18-foot non-telescoping boom which allows the picker to rotate in both the horizontal and vertical planes from the center of the machine. In these trials the pickers placed the fruit into three picking bags attached to the sides of the bucket. They could reach fruit to a height of about 30 feet from the machine and used a pole picker for any above their reach. The manufacturer can supply a variety of receptacles or a belt system to lower the fruit to the base of the machine.

The test period was for two weeks in January 1967. The variety being harvested was Zutano from 17 year old trees planted at a 15 foot by 25 foot spacing. The heights of the trees varied from 20 to 40 feet. The land was nearly flat, the orchard nontilled, and with portable sprinkler irrigation, there were no furrows or other ground obstacles to hinder free movement of the machines.

For this trial experienced avocado pickers from the regular Calavo crews were used. They were observed first in their conventional picking procedures using 10-foot 3-legged, and 28-foot extension ladders and 28-foot extension ladders and several lengths of picking poles. All fruit was clipped, picked into conventional bags and emptied into standard field boxes.

Figure 1—Selma Tree Master used in picking avocados.

Three pickers were oriented to the two machines and allowed to pick for four days before using their performance data. However, there was no noticeable change in picker productivity after the first couple of hours on a machine.

Data for crew comparisons came from 769 boxes of fruit picked from the machines and 217 boxes of fruit picked from ladders and the ground. Detailed time and motion data were collected while picking 40 boxes by machine and 18 boxes by ladder. The average yield was 4.9 boxes per tree or 23,000 pounds per acre.

COMPONENTS OF AVOCADO FRUIT PICKING

The orchard operation of picking fruit can be separated into a number of logical functions and components based upon their nature and the way operations influence their times of performance. Tables 1 and 2 give a breakdown of the orchard operations used in this study, to compare the Selma Tree Master with conventional ladder and pole picking.

Harvesting can be separated into two general functions of fruit removal from the tree and fruit handling after removal in the orchard. Each of the two general functions are further divided into operational components which in turn are divided into operational subcomponents.

Fruit removal assumes a three-dimensional relationship where movement to and the picking of individual fruit dominate the function. Therefore, conditions that exist in the tree, such as fruit location and volume, and tree size and configuration, tend to have the greatest effect on this function.

In contrast, fruit handling after removal is more a typical management and engineering problem of moving and loading of fruit for transport to the packing house. Therefore, orchard factors, such as orchard layout and volume of fruit handled for a given area, tend to have the greatest effect on this function and times.

MOVEMENTS WITHIN THE TREE

For conventional ladder and pole picking, the time consumed to move and set ladders, to climb and otherwise prepare to pick fruit are sizeable inputs of labor. The time data are presented in Table 1. The pickers spent 45% of their movement within the tree in moving and setting ladders. Another 45% of their time was spent climbing up and down the ladders and looking for fruit.

Table 1 — TIMES OF COMPONENTS IN LADDER & POLE PICKING

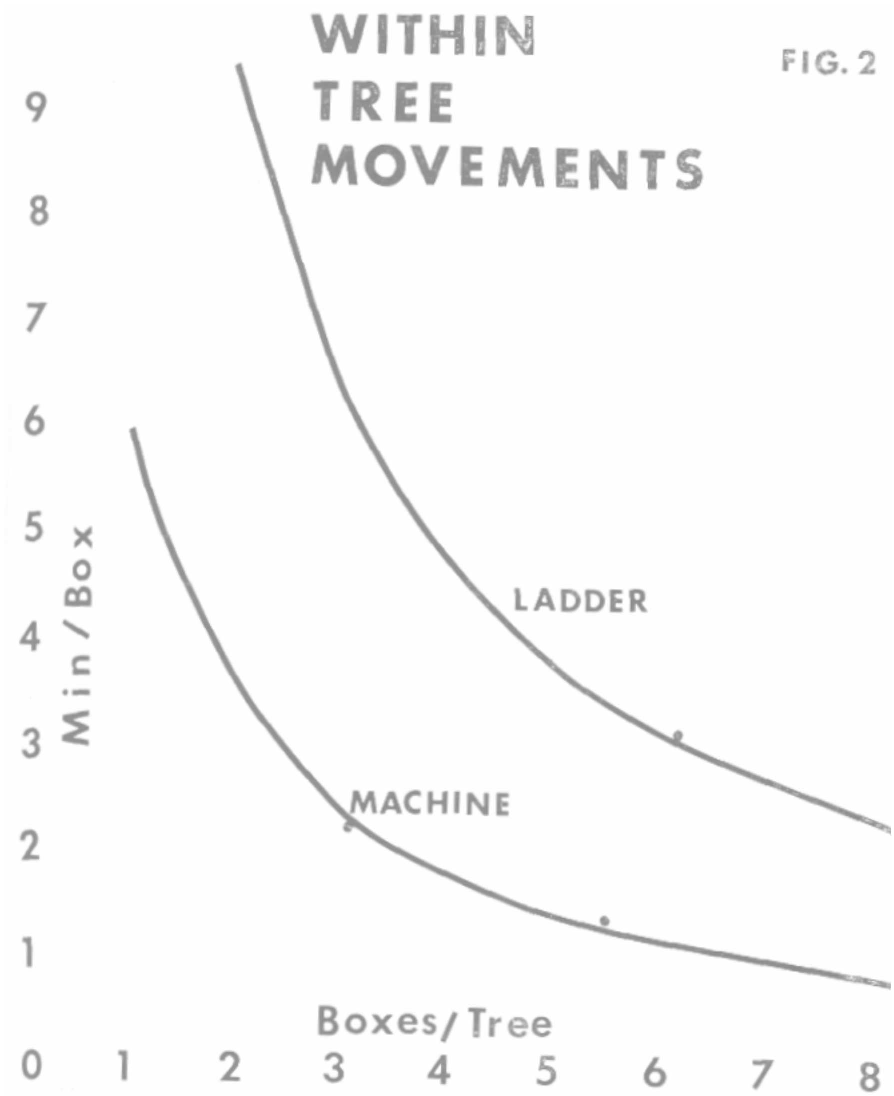
COMPONENTS and Subcomponents	*Minutes/field box*
MOVEMENTS WITHIN TREE	
Set Extension Ladder	1.24
Set Three-Legged Ladder	.16
Movement Within Tree	1.37
Miscellaneous	.34
Movements Subtotal	3.11
NET PICKING	
With Poles	.96
Cut Stems on Ground	.80
Pick Skirts	.33
With Three-Legged Ladder	.62
With Extension Ladder	4.06
Net Picking Subtotal	6.77
FRUIT TRANSFER	
Picker to Box	.26
Dump Fruit	.23
Smooth and Stack	.39
Picker to Tree	.21
Transfer Subtotal	1.10
TOTAL Time by Ladder and Pole	10.98

**The time differences for the operational subcomponents for the three pickers were no greater than what would be expected from normal variations so, in this paper, only the over-all averages are given.*

The average of 3.11 minutes per field box for conventional harvesting movements compares to 1.15 minutes under similar conditions for movements from the Selma Tree Master. This favorable comparison for movements within the tree results partly from the apparent difficulty pickers have in setting and climbing ladders because of the brittleness of avocado limbs and the relatively large amount of climbing needed to get to the fruit.

The more or less spreading nature of avocado limbs with openings within the tree, as opposed to the more solid shell of the typical citrus tree, allows a more effective use of the machine design employed by the Selma firm. The machine appears to work if its base is kept in the center of the row and the machine body kept oriented parallel to the row direction for all picker positioning movements.

Movement time within the tree is more or less directly proportional to the special area covered; therefore, for a given size tree, this time component should take on a hyperbolic relationship with yield per tree. The data was not extensive enough to check this in detail, but it appears to fit, as illustrated in Figure 2. Note that the vertical distance between curves is much greater in low yields.



For example, at 7 boxes per tree the distance between curves is 1.7 minutes while at 3 boxes it is about 4.0 minutes. If this is the case for movements within the tree, the machine advantage increases as the yields per tree become smaller.

NET PICKING

Picking while in position, or net picking, includes searching, reaching, clipping, and placing fruit in the bag. The rate is affected by such main factors as fruit density, distance between fruit and picker, pouch size and location, fruit size, stem characteristics, leafiness of tree, picker orientation, platform stability, and freedom of various picker body members.

Of real importance in avocado picking is the need to use a picking pole for fruit which cannot otherwise be reached due to height or inability to set a ladder. From limited time data, one picker averaged 17.8 fruit a minute without the pole. This 3 to 1 ratio was measured while picking on the Selma machine and gives a rough measure of the advantage of replacing the pole. Also, pole-picked fruit must be rehandled to cut off the long stems.

The time data for the fruit picked by ladder and pole totaled 6.77 minutes per box. If adjustments were made to eliminate the effect of picking with a pole, the average total time would be 5.95 minutes per box of fruit. The comparable rates for net picking by machine averaged 3.40 minutes per box.

Thus, the over-all time saving of the machine in net picking was from 6.77 to 3.40 minutes per box, or nearly 2 to 1. About one-quarter of this saving was due to the reduction of pole use.

FRUIT TRANSFER

Transferring fruit from the picker's work station to a field container is largely unrelated to fruit, tree, and most orchard factors, but closely related to picking systems and management practices used. Fruit transfer includes all the time from when a picker leaves a picking position to unload the fruit until he gets back to a picking position. This includes all movements to and from the boxes, dumping, smoothing the fruit, stacking containers, recording and other associated activities. It also includes help from others in the transfer operation in the case of the machine.

Field boxes were placed as close as possible to picking operations, usually no farther than the adjoining middle. Extra time required to round up boxes, load, unload, etc. were classed as 'Further Handling' and were not considered part of this comparison.

The subcomponents of fruit transfer for ladder and pole picking observed during this trial are given in Table 1, and total a little more than one minute per box. The similar breakdown for machine picking is given in Table 2. Because the three picking bags were attached to the bucket, it was necessary for an assistant to hold a field box beneath each bag as the picker released the fruit. Thus, the total fruit transfer time for machine picking, including both picker's time of .66 minutes per box and the assistant's of .97 was 1.63 per box.

Table 2 — TIMES OF COMPONENTS IN MACHINE PICKING

COMPONENTS and Subcomponents	*Minutes/field box*
MOVEMENTS WITHIN TREE	1.15
NET PICKING	3.40
FRUIT TRANSFER	
Picker to Unloading	.12
Dump Fruit	.28
Close Bags, etc.	.06
Picker to Tree	.12
Subtotal Picker Time	.66
Assistant to Machine	.08
Dump Fruit	.48
Smooth and Stack	.41
Subtotal Assistant Time	.97
Subtotal Time Fruit Transfer	1.63
TOTAL Time by Machine	6.18

A comparison of Tables 1 and 2 illustrates that the assistant in fruit transfer spends approximately the same amount of time that the ladder and pole picker does for the same function -- about one minute per box. This seems logical for the same container and orchard conditions. Thus, the additional time required for this function is that time spent by the picker.

Even though this machine fruit transfer time was considerably higher than with conventional picking, the possibility exists in other machine arrangements for a reduction in time for this function. For example, if continuous removal devices were installed which would transfer picked fruit directly to field containers at the base of the machine, a saving of one minute per box might be realized. At an average picker rate of 80 boxes per day, this would allow a picker to harvest 16 boxes more. If we assume it costs $.45 to pick a box and if we assume, for the fruit conveyor system, an average hourly cost of $.35, a 3-year life, interest at 6% of the average investment, and other overhead costs at 4%, we could justify an extra investment of about $1,200 for fruit handling.

Comparing Ladder and Pole with Machine Picking

Based on the time and motion studies as shown in Tables 1 and 2, the rate of avocado picking was reduced from 10.98 minutes per box for conventional methods to 6.18 minutes per box by the Selma machine. Thus, machine picking appears to be about 78% more efficient than ladder and pole picking under these optimum conditions.

However, when the two picking systems are compared on an overall 3-man crew basis, using the field sheets kept by the ranch, the increased efficiency is on the order of 59%, as shown by Table 3. The average rates of pick were 11.9 minutes per box for the 3 men with ladders and poles and 7.5 minutes per box using two machines and the foreman on the ground.

Figure 3—Fruit transfer from picker's work station on machine to field box held by ground assistant.

Table 3 — CREW COMPARISONS FROM FIELD SHEETS

IN FIELD BOXES per Hour	*Picker #1*	*Picker #2*	*Foreman*	*Crew Average*
Ladder & Pole System	5.2	5.9	2.8	5.0
Machine System	10.5	10.8	2.8	8.0
In Minutes per Field Box				
Ladder & Pole System	11.58	10.24	21.66	11.88
Machine System	5.73	5.58	21.35	7.49

Recognizing that the time and motion data gave an optimum efficiency increase potential of 78% and the crew average under the favorable trial conditions produced a 59% increase, it seems appropriate to conclude that it is possible to expect efficiency increases on the order of 67%. Observations in other orchards would suggest that the benefits of machine use would be less. More trials are needed to evaluate this machine in different, orchard conditions.

Costs of Machine Operation

To test the economics of this increased efficiency (a labor saving) the added cost of machine operation must be considered. From the limited information available, the cost data presented in Table 4 has been synthesized for this trial.

Table 4 — SELMA MACHINE COSTS OF OPERATION

Annual Overhead Costs		
Original Cost of Machine		$ 4,000
Estimated Life—years (5)		
Annual Depreciation	$ 800	
Interest on Investment, 6%	120	
Taxes, Insurance, Housing, etc.	80	
Total Annual Overhead Costs	$ 1,000	
Cash Operating Costs per Hour		
Fuel ($2\frac{1}{2}$ gals/8 hr. day)	$ .15	
Service, Repairs, and Maintenance	.35	
Total operating costs per hour	$ .50	
Total Costs by Hours Used Annually		
500 hours annual use =	$2.59 per hour	
750 hours annual use =	1.83 per hour	
1000 hours annual use =	1.50 per hour	
1250 hours annual use =	1.30 per hour	
1500 hours annual use =	1.17 per hour	

Overhead costs for the machines used were estimated to run about $1,000 each per year. Operational costs per hour are quite low and a generous allowance of $.50 per hour was set.

Hours of use annually would change the total cost rate per hour markedly. The typical harvesting season in the Santa Barbara area might run at least 10 weeks or about 500 hours. If a machine operator were to use it to its maximum during a season, he might accumulate as much as 1500 hours annually. If we assume a machine is used 1000 hours annually, its total hourly cost would be $1.50.

Assuming a labor cost of $.45 per field box, with the added production of 4.5 field boxes per hour per machine, based on the rates shown in Table 4, the benefit available to offset the machine costs would be $2.03. The machines at the 1000-hour level would cost $1.50 per hour, leaving a $.53 per hour saving. Using these assumed figures, each machine would need to be used for 650 hours each year to break even with the labor saved. This is assuming no change in the wage rates paid to pickers; no attempt was made in this study to consider wage rates, but could be the subject of further study.

From this it appears that the Selma Tree Master, in comparison to ladder and pole picking, under favorable picking and crew conditions, can at least break even and provide a saving under good management.

Crew Arrangements and Other Considerations

The crew arrangement used in these tests of the Selma Tree Master was three men to two machines, where one crew member, the foreman, picked the skirts of the trees and helped transfer fruit from the machines. From Table 2, we saw about 46% of the assistant's time was spent helping with fruit transfer from the two machines. Thus, one ground assistant could handle about four machines; another man would probably be needed to pick the skirts. So it would appear that these machines could be used in either 3-man or 6-man size crews. The advantage of the 6-man crew would be the probable reduction in overhead costs for the foreman. For the 3-man crew, the advantage would be the increased operational flexibility. But further testing in other orchard conditions would be needed to verify these crew size ideas.

Picker reaction to the machines appeared to be favorable and they preferred the machines to ladders and poles. The machines' performances were quite reliable and, under the test conditions, picking appeared to be safer from this machine than from a ladder.

Observations during this trial suggest that the machine provided no increased efficiency below about 14 feet. The skirts of the trees up to about 12-14 feet can be just as easily harvested from the ground and a 10-foot, 3-legged ladder. Thus, the proportion of the crop to be harvested in the upper part of the tree will be a major determinant on how efficient machine harvest will be.