



# Cost comparison of hand and mechanical harvest of mature green tomatoes

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*Under some conditions, mature green tomatoes can be picked as cheaply by a highly productive hand-harvest crew as by machine.*

California produces about 30 percent of the fresh market tomatoes in the United States, half of which are shipped as mature green tomatoes. California mature green tomato crops are grown in four regions with production in three seasonal categories—early spring, early summer, and early fall. Northern and central San Joaquin Valley and the Salinas Valley accounted for 92 percent of the shipments from the state in 1977.

Mature green tomatoes were harvested solely by hand until 1977, when machine harvesting was introduced. During the 1980 season, several California shippers used machines to harvest all or part of their crop. The machines essentially are modified processing-tomato harvesters, which the manufacturers anticipate will allow little damage to the tender fruit.

The objective of this study was to describe and compare hand and machine harvest systems. The costs are derived both from observation and from use of standard costs where appropriate.

The length of the operating season varies, depending on the area. Some seasons are short—from four to five weeks—and others last two or more months. Growers commonly

extend the season by operating in two or more areas. Tomato yields in the field range from 12 to 20 tons per acre, but packout from the shed is about 25 percent less.

## Harvest systems

The hand harvest crew is organized around the pickers. A crew that we judged as representative had a total of 36 workers: 27 pickers, 2 checkers, 2 bucket handlers, 2 dumpers, 1 row boss, and 2 tractor drivers. The pickers select the fruit, remove it from the vine, and place it in a bucket. After picking two buckets, the picker carries them to the gondola, where a checker punches the picker's ticket, and the buckets are handed to a bucket handler. The handler hands the buckets one at a time up to a dumper, who empties them into the gondola. The empty buckets are returned to the picker, who goes back to his or her picking row to repeat the process.

For cost comparisons, we used two labor productivity rates and two wage rates for hand harvest labor. The productivity rate varied widely. Cost studies and observations indicated that typical crew output at minimum hourly or low piece rates was about 10 buckets per picker hour (25 pounds per

bucket). At the other extreme, under an incentive wage system, hand harvest crews picked 38 buckets per picker hour. We examine both rates here: a minimum hourly wage rate is associated with the 10-bucket-per-hour productivity, and a wage rate one-third higher than minimum is associated with the higher productivity.

For the pickers, piece rates were based on the minimum wage rates or one-third higher than minimum. Thus, at the low productivity, pickers received the low piece rate times 10 buckets per hour; other crew members received their hourly wage. At the higher productivity, pickers received the higher piece rate times 38 buckets per hour, while other crew members received rates one-third higher than minimum.

Two tractors and a pickup were used per hand crew, along with associated equipment (tables 1 and 2). Total operating costs per hour were \$9.69 for equipment and \$141.79 for labor. Average fixed costs for 180 hours were \$57.07 per hour (table 3). The total cost for the hand harvest crew for the 180 hours of operation was \$208.55 per hour. At the crew output of 10 buckets per picker-hour for a yield of 16 tons of tomatoes, the cost per ton



was \$62.06. In comparison, extending the season to 432 hours under the same assumptions would lower the cost 26 percent to \$52.16 per ton. Costs of hand harvesting at the high wage and productivity rates were \$49.81 and \$47.15 per ton, for season lengths of 180 and 432 hours, respectively.

The machine harvest system is similar to that used to harvest processing tomatoes. The machine, usually with a crew of 1 operator, 20 sorters, 1 elevator operator, 3 tractor drivers, and 1 supervisor, harvests one row at a time. The vines are cut, picked up, and lifted to the shaker bed; the shaker bed removes fruit from the vine; and the fruit falls onto cross conveyors, which take the fruit past sorters, who work on a platform on each side and along the back of the machine. The elevator lifts sorted fruit into a gondola on a trailer, which is towed through the field alongside the harvester. Truck tractors haul full gondolas to the packing shed. The machine is operated at 0.5 mile per hour with a 75 percent field efficiency. The machine can cover an acre in two hours.

For cost purposes we used a crew of 26, including 20 sorters, and two wage rates, one at the minimum wage for the sorters (other crew members received somewhat more) and the other at wages one-third higher.

Machine investment and operating costs (tables 1 and 2) for a 180-hour season were \$276.41 per hour. Combined with labor cost, the total cost over the season was \$383.28, or, at a crop yield of 16 tons, \$47.91 per ton (table 3). At the one-third higher wage costs, a season extended to 432 hours, and a yield of 16 tons per acre, the total cost was reduced 27 percent to \$35.07 per ton. Even with the higher wages, extension of season length permitted large economies.

## Harvest costs compared

Two hand systems were compared for fields yielding 16 tons per acre, one at low crew output and minimum wages, and the other at high output, and one-third higher wages and higher piece rates (fig. 1). Costs were lower for the high productivity crew in all lengths of season, but especially in the short season. For instance, the cost of the low-output crew in a season of 100 hours (two to three weeks) was \$76.50 per ton; that for the high-output crew was \$53.50, a decrease of \$23 or 30 percent. In longer seasons, however, costs were much closer: high-output-crew costs were only 7 percent lower at 600 hours.

Machine harvest becomes less costly than hand harvest at around 100 hours when compared with the low-output crew and at 200 hours when compared with the high-output crew. In the long season of 400 to 600 hours (two to three months), machine harvest costs



Sorting mature green tomatoes on a mechanical tomato harvester.

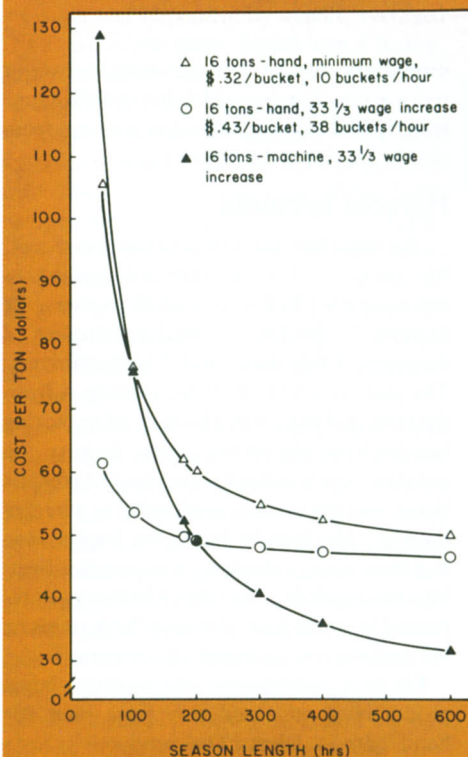


Fig. 1. Total costs of hand and machine harvest systems at various hours of operation, wage rates, and productivities.

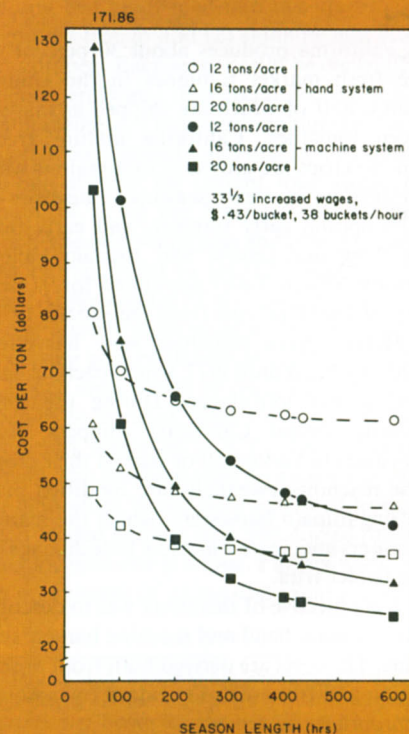


Fig. 2. Total costs of machine and high-output hand harvesting compared at selected yields for various operation hours.



**TABLE 1. Fixed Costs of Individual Items Used in Harvesting Mature Green Tomatoes, 1980 Season**

Equipment	Number required	Replacement cost \$	Life years	Total fixed cost per season \$
<b>HAND HARVEST</b>				
Buckets	80	280	3	115
Tractors (50 hp)	2	26,000	10	4,925
Tubs (gondolas)	4	8,638	10	1,633
Dollies	2	2,650	10	501
Pickup — ¾ ton	1	9,000	5	2,780
Toilets (rental)				318
Total				10,272
<b>MACHINE HARVEST</b>				
Harvester	1	94,000	5	27,207
Tractors (50 hp)	3	39,000	10	7,388
Undercutting equipment	1	1,800	10	341
Tubs	4	8,628	10	1,634
Dollies	2	2,650	10	502
Pickup — ¾ ton	1	9,000	5	2,780
Truck — 1 ton (mechanic)	1	11,000	10	2,270
Toilets (rental)				318
Total				42,440

**TABLE 2. Equipment Operating Costs Per Hour for the Mature Green Tomato Harvest Systems, 1980 Season\***

Equipment	Hand system		Machine system	
	Number used	Operating cost/hour \$	Number used	Operating cost/hour \$
Tractor (50 hp)	2	7.90	2	7.90
Pickup — ¾ ton	1	1.56	1	1.56
Mechanical harvester	—	—	1	26.96
Tractor (50 hp) (½ time)	—	—	1	1.31
Truck — 1 ton	—	—	1	1.91
Interest on operating capital	—	0.23	—	0.99
Total operating cost per hour	—	9.69	—	40.63

\*Costs are calculated per hour to facilitate comparison of systems with varying productivities, wage rates, and yields.

**TABLE 3. Cost Summary for Mature Green Tomato Harvest Systems at Selected Season Lengths, Wage Levels, and Productions, 1980 Season**

Item	Hand systems		Machine system
	Minimum wage for 10 buckets/hr \$	Minimum wage + ⅓ for 38 buckets/hr \$	Minimum wage \$
<b>Season length — 180 hours (5 weeks)</b>			
Labor, per hour	141.79	570.83	106.87
Equipment			
Operating costs, per hour	9.69	9.69	40.63
Fixed costs, per hour	57.07	57.07	235.78
Total cost per hour	208.55	637.59	383.28
Total cost per acre*	993.09	796.99	766.56
Total cost per ton at 16 tons per acre	62.06	49.81	47.91
<b>Season length — 432 hours (12 weeks)</b>			
			Minimum wage + ⅓
Labor, per hour	141.79	570.83	141.70
Equipment			
Operating costs, per hour	9.69	9.69	40.63
Fixed costs, per hour	23.78	23.78	98.24
Total cost per hour	175.26	603.50	280.57
Total cost per acre*	834.57	775.38	561.14
Total cost per ton at 16 tons per acre	52.16	47.15	35.07

\*Total cost per acre =  $\frac{\text{total cost per hour}}{\text{acres per hour}}$  For example,  $\frac{\$208.55}{0.21} = \$993.09$ , and  $\frac{\$637.59}{0.8} = \$796.99$ .

about 25 to 30 percent less than high-output hand harvest and 32 to 36 percent less than low-output.

When machine and high-output hand-crew harvesting are compared at selected yields, the major effect of changes in yield is that harvesting costs decline with yield increases (fig. 2). When yield increases by 8 tons, costs per ton are reduced by about 40 percent.

## Comments and conclusions

The eventual success of mechanical harvesting of fresh tomatoes depends on at least two factors. One is the eventual adaptation of the mechanical harvester so that it can handle the fruit with a minimum of physical damage under a wide range of physical conditions. Harvesting mature green tomatoes presents a number of problems, regardless of the system used. Injury to the fruit during handling affects quality and shelf life. Some of the handling injury is not visible at the packing shed but appears at the store, when rot organisms enter the fruit at the location of the injury.

The two common injuries are abrasions or scuff marks and bruises. Dirt and clods on the conveyor belt cause abrasions which may be reduced by improvements in cutting vines and in the pickup mechanism. Bruising results from stems and fruit being dropped too far. Improved cultural practices will have to be adopted to reduce the clod and dirt problem.

The other factor is development of suitable tomato varieties. Seed company and experiment station plant breeders are developing varieties for machine harvest. Several open-pollinated and hybrid varieties are available, but improvement is needed, particularly in stem detachment and fruit firmness.

There are two general effects on labor that we should mention. One is in the comparison of hand crews. The incentive rate for pickers provides the opportunity for the crew to earn substantially more income than would otherwise be available under hourly wage rates. At the high productivity and high wage rates, a picker can earn about \$16 per hour (38 buckets per hour x \$0.43). Further, the high-productivity-crew harvest costs are competitive with the machine costs, especially in seasons of short to medium length.

The second effect is the change in number and type of workers needed for the machines. Machine crews are 28 percent smaller than hand crews. Although this is not a large number, the skill requirements would be changed, from picking to sorting skills.

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