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Many Fewer Steps for Pickers—A Leap for Harvestkind? Emerging Change in Strawberry Harvest Technology

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Strawberry harvesting, one of the most labor-intensive operations in production agriculture, is becoming less so. A recently developed machine has altered the harvest system in a sizable share of Ventura County, California, acreage this year, and it appears headed for wide adoption.

The technological change this machine brings is short of revolutionary. Its effects will not be comparable to those of the tomato harvester or cotton gin. Nevertheless, it is reducing human work time by one third or more and altering the mix of motions and postures in harvest work.

Use of the machine-aided system raises an array of issues that refine the classic economic question of whether future labor savings provide a sufficient return to an immediate investment. Growers contemplating or already adjusting to the move face interrelated decisions about harvest crew configuration, work pace, pay scheme, ergonomic risk control, and overall choreography of introducing the change.

Innovation in Agriculture

As both a source of commodities and an economic engine, U.S. agriculture has long relied on development and application of biological, chemical, information processing, and mechanical advances. New technologies have been designed to achieve a variety of private and social benefits, such as increasing crop yields and quality, conserving water and energy, better targeting fertilizers and pesticides, and reducing personal exposure to hazards. Almost always, however, a key objective for mechanical innovations is to increase labor productivity.

Changes in the nature of jobs have accompanied reductions in labor intensiveness. Adoption of the mechanical cotton harvester, for example, nearly halved the labor bill in that commodity while saving producers 15% of their total operating costs from 1950 to 1970. Concurrent with a sharp reduction in total employment, the average wage for remaining cotton production jobs increased along with the levels of reliability and skill required to do them. Such changes have occurred more in field crops and livestock than in fruits, vegetables, and horticultural specialties. Generally, mechanization is more applicable to tasks that are strenuous or repetitive and processes to which inputs are relatively uniform (e.g., lifting bins, plowing fields, threshing wheat, harvesting sugar beets).

Operations on variable or fragile inputs under less predictable conditions (e.g., pruning grape vines, thinning peach trees, picking strawberries) require sensory perception, judgment, and manual dexterity. They call for human work and employ many people, despite the dramatic decline in the overall size of the U.S. farm workforce since 1900 (Figure 1). Costs for hired labor range up to one quarter of total agricultural production expenses in states with large specialty crop sectors, and harvest labor is the single largest operating cost in some high-value/acre commodities.

Hopes spring eternal for developments that would minimize the arduousness, seasonal swings, and transaction and social costs of short-term farm

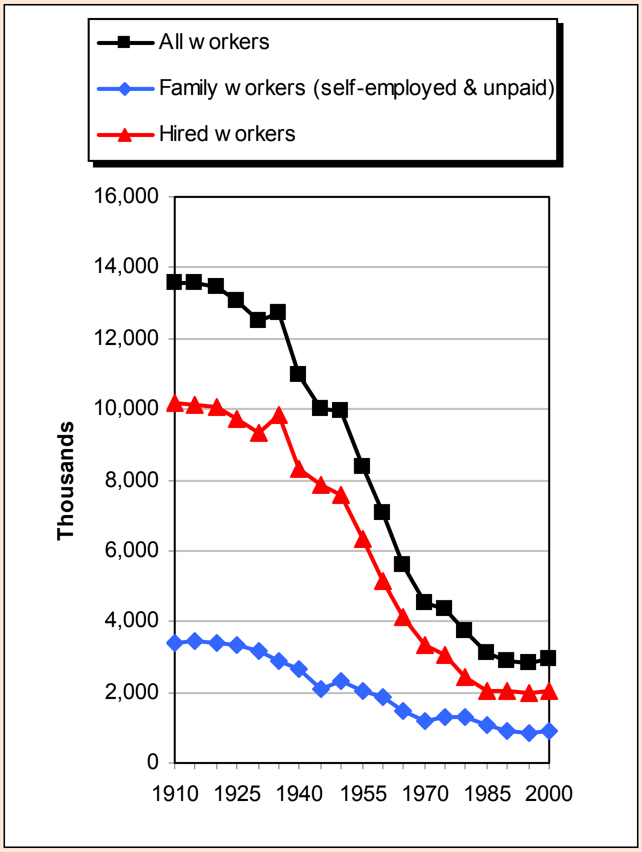

Figure 1. U.S. farm workers by type, 1910–2000.
Note. Data from USDA NASS, June 2002.

jobs. Future mechanization, in concert with biotechnology, may someday replace more strenuous cultivation and harvest jobs while lengthening careers in agricultural fieldwork. For now, however, much production still depends on availability and willingness of people to perform difficult manual work for brief periods. Although it does not reduce the need for human eyes, judgment, and hands in the most critical strawberry-harvesting tasks, the new machine substantially reduces a lower-skill part of the harvester's job. As with all innovations, however, its intended benefits are not assured, and its use may have unexpected impacts.

Strawberries in California

Strawberries are the fourth most valuable fruit crop produced in the United States, and they rank second only to apples in fresh market sales. California growers produced 1.4 billion pounds of strawberries (83% of the nation's total) worth some $800 million in 2001. About three fourths were harvested for the more lucrative fresh market, the rest for freezing and processing. Highly productive cultivars, research-based cultural and pest control practices, rich sandy soil, and moderate coastal temperatures that support long, regionally overlapping growing seasons all contribute to California's large yield and market share advantages.

Strawberry production is expensive and labor intensive. Total production costs are around $25,000/acre, of which harvesting accounts for about 63%. Harvest labor expense alone is more than 40% of the total (see http://coststudies.ucdavis.edu./outreach/crop/crop/strawberries.htm). Statewide employment in berries peaks at nearly 30,000 in May and June.

Harvest Work

Strawberry plants continuously produce new fruit that is hand-harvested in a three-day rhythm over the season. In the traditional technology, harvest crews of 25–35 members retrace an itinerary through planted acreage twice during a six-day workweek. Workdays normally lasting seven to nine hours are sometimes shortened by bad weather or field conditions.

The job of harvest worker includes a cycle of tasks that require concentration, dexterity, and stamina. Tasks of selecting, picking, and packing ripe berries are performed in rapid sequence. Interspersed with them is the task of cleaning the plants of berries that are misshapen, bruised, moldy, or otherwise unmarketable. The final task in the job cycle is delivering full trays ("flats") to a collection point (typically on a road that borders the field) and then returning to the row with an empty flat. A checker at the collection point controls quality and records individual output, and a stacker piles the flats for loading on a truck that takes them to a cooler.

Rows are normally 300 feet long, and a collection station is set up at each end of the field. Workers take their finished flats (one at a time in most firms) back up the row and then laterally on the road to the station, so that the round-trip walk between picking area and delivery table averages 240 feet. Managers report that a majority of injuries during harvest are due to slips and falls near the end of the row, where workers turn sharply as they hurry in with a full flat or back out with an empty.

Core tasks of picking and plant cleaning must be performed while bending, kneeling (usually with one knee on the raised bed), or crouching. Workers use both hands to gently grab, twist, and snap off the berries they select. Although they shift from one side of the row to the other, occasionally stand up for a breather, and often change positions in other ways, most of their picking time is spent in postures that are widely seen as physically demanding. Union leaders and other worker advocates have expressed great concern about long-term effects of these postures and workers' repetitive task motions on their bodies, especially backs. Bills that they have sponsored in the California legislature would prohibit "weeding, thinning, and hot-capping in a stooped, kneeling, or squatting position" (i.e., by hand), except in narrowly defined circumstances. A petition to similarly restrict these activities through administrative regulation is under consideration by a Cal/OSHA advisory committee.

Machine-Aided Harvest

The new machine serves as a mobile station for receiving and accumulating packed flats of berries close to where they are picked. It slowly creeps down the field just ahead of where harvesters are picking. By allowing for immediate delivery within every row, it eliminates bottlenecks at a central collection point on the road as well as the need to walk or run more than two miles per day down the row with a full flat. Its function is similar to that of machines long used in lettuce and celery harvest, but it changes the jobs of people who work behind it differently.

Conceived by a Ventura County grower, a prototype was fabricated and first field tested in 2000. Experience and adjustments accumulated, allowing introduction of a third generation of machines in February 2003 that served reliably through the spring season in Ventura County. Safety-oriented adjustments (e.g., hazard warning signs, protective gear for machine operators, remote engine-kill switches, an additional first-aid kit) were made during the season, and additional refinement of the machine is likely for the 2004 season. Local observers estimate that 50 machines were used to help harvest 30–40% of the Ventura County strawberry acreage in 2003, compared with only ten machines on an experimental basis in 2002.

Manual Harvest of Strawberries

Top: Workers fill strawberry flats and carry them along the row...
Middle: ...then turn sharply at the end of the row as they hurry in or out with flats.
Bottom: A checker at the collection point records individual output.

Machine-Aided Harvest

Top: The machine slowly creeps down the field just ahead of where harvesters are picking.
Middle: Once completing a flat, a worker walks a short way and puts it on a shelf that runs along the machine boom.
Bottom: Operator/stackers lift flats onto a platform for checking, individual output recording, and intermediate stacking.

Workers in the machine-aided system shown in the accompanying photos pick and pack berries exactly as in a traditional harvest. Once completing a flat, however, they walk only a short way and put it on a shelf that runs along the machine "boom," which extends across 15 rows. There they write on the flat a number that identifies it as theirs, adjust berry placements, insert stacking guide wires, and then move the flat forward to a conveyor belt. Two belts, one each on the left and right halves of the boom, move flats from all rows to an open area at the center, where one of two operator/stackers lift them onto a higher platform for checking, individual output recording, and intermediate stacking. From there the flats are stacked onto pallets that are directly offloaded by a forklift and taken to a truck bound for the cooler.

This machine continues a gradual substitution away from manual conveyance in strawberry harvest. Only within the past several years have forklifts become commonly used to load stacks of finished flats onto trucks. Previously, the lift/load operation mostly taxed human arms, legs, and backs.

The harvester job changes touched off by the new machine in berries are not the same as those in vegetables, where formerly "ground crews" working without machines had left their packed cartons (much heavier than berry flats) in the row for pickup and loading onto a truck that was brought near. Lettuce harvesters never had to deliver the boxed product to the edge of the field. Moreover, the machine effect on harvester posture was different. Because they left harvested heads on the ground for packers following them, cutters in a lettuce ground crew spent longer periods in a bent or kneeling position than they do in machine crews, where cutters have many more ups and downs but stand erect while trimming and handing heads to packers sitting on the machine.

Important Outcomes

How will a move to machine-aided harvest play out for growers and workers? Growers can, of course, expect to incur new expenses of purchasing (or leasing) and operating the machine and to save on harvest labor cost. They also may realize gain or loss from changes in berry pack quality, capacity to meet unexpected surges in demand, employee absenteeism and turnover, ease of recruitment, and injury experience and related workers' compensation premiums. Potential returns on the $125,000 investment for a third-generation machine look good, but actual results will depend on many decisions in the field and office.

Use of the machine to reduce the time and burden of carrying full flats can translate into harvest worker-hour savings of one third or more. In one firm, a machine crew of 15 pickers performed the work that a traditional crew of 25 had in previous years. In a 50-hour workweek, the machine replaced 500 worker-hours. Using $10 as a conservative (low) estimate of direct and indirect hourly labor costs, those hours saved are worth a gross of $5,000 per week—$70,000 over a 14-week Oxnard spring season, $130,000 over 26 weeks in Watsonville, and as much as $195,000 if the machine could be transported and serve non-overlapping regional seasons during nine months (39 weeks) of the year.

Partly offsetting this gross cost saving are investment opportunity cost, downtime, and current expenses for fuel, maintenance, repair, and transportation from region to region. An engineer estimates the cost of machine operation and maintenance as equivalent to a daily rental, about $200, or $1,200 for a six-day week. Assuming further that opportunity cost and potential investment tax credits balance out, the net system savings come to $3,800 per week, $53,200 for a 14-week season, $98,800 for 26 weeks, and $148,200 for nine months. At first glance, then, adoption of the new technology is economically compelling, even at today's prices. Moreover, costs for the machine and for human work hours are probably headed in different directions. Cost of the machine should ease as R&D phases down and units are produced on a larger scale. A key managerial decision is how to allocate portions of this saving to machine purchase repayment, worker wages, and operating profit.

What is in the deal for harvest workers? Key measures of their economic interest as individuals are earnings per hour and total earnings over the season. Although number of jobs and the total wage bill are smaller in a machine-aided system, remaining harvest workers could achieve much higher earnings, if growers structure their pay systems to share efficiency gains. Although pay plans differ within the industry, the vast majority include a piece-rate component. Many firms pay an hourly rate plus an output-based supplement, such as $4.60 per hour plus $.80 per flat, and many pay totally on a piece-rate basis, all guaranteeing workers $6.75 or more per hour for all time worked when piece-rate earnings would not meet that California legal minimum.

By reducing the time needed to complete a flat production cycle, the machine enables harvesters to turn out more units in a given time period. The more that pay is based on output (i.e., a piece-rate applied to number of units) and the closer the piece rate is to the non-machine rate, the greater the increase in worker earnings. If pay is based entirely on time (hours worked), and the hourly rate and length of workday remain the same, individual harvesters earn exactly the same under both technologies, and the grower would reap all the efficiency gain to cover machine costs and improve operating margins.

Management of a company that had paid a straight piece rate of $1.50/flat has opted to roughly split the machine system savings with harvesters (when the fruit is dense enough to support piece-rate pay). After consulting with crewmembers, it set the machine-aided piece rate at $1.20, 80% of the prior level. Because the 15 harvesters each produced an average of 67% more flats than the 25 in the crew had without a machine, their piece-rate earnings came to about one third more (167% x 80% = 1.33) than they had been.

The harvestable fruit does not support piece-rate earnings, however, in every pay period over a season. When the harvesters do not produce enough flats to earn at the minimum wage rate, for whatever reason, their pay is calculated on a time basis (rather than output) at the legal minimum rate, currently $6.75 per hour. Not only the rate of earnings but also the work pace fluctuates, as pickers do not go full speed when they see little chance of output-based pay exceeding the hourly guarantee.

Physical as well as mental reactions to the changed job and work environment—particularly the decrease in time spent carrying flats and the increase in picking and packing—will be important to monitor. The moves (bending, kneeling, crouching, reaching, repetitively grabbing) required to perform the latter tasks are linked more with risks of musculoskeletal injury. Carrying is performed upright but involves more risk of slips, falls, and twisted joints while hustling down narrow, sometimes uneven, or slippery rows.

Unease about overall equity of the new arrangement also may counter any boost in earnings for workers. If 15 people plus machine perform the work formerly done by 25, each person picks an average of 67% more berries and tends to 67% more plants apiece while bending, kneeling, or crouching. Extra time spent delivering full flats under the traditional system may have been valued as a respite from stress of working in a non-erect posture. It remains to be seen whether workers will find comparable relief in the shorter walk to a machine, perhaps supplemented by more frequent stretches in place.

More subtle considerations from the workers' perspective are the noise emitted by the machine and the unique place the machine has for each worker to take completed flats. That place might be customized as a kind of "workstation" at which water containers, clothing, and personal items can be stored.

Management Choices

The strategic decision to adopt a different technology is clearly not the only important choice affecting results. Costs, benefits, and ultimate success of a transition to machine-aided strawberry harvest depend on synchronizing the attributes and use of the machine with those of the people whose labor remains the most essential factor of production. Decisions related to the machine technology involve:

Worker-machine interface. How high should the staging shelf be and how close to the conveyor belt? What devices or modifications could be made for storing personal items? Are signs needed to inform about hazards?

Crew configuration and membership. Does work in a machine crew require a different orientation or set of abilities than in conventional crews? Will employee recruitment, selection, and assignment be designed to create crews of people who work at a similar pace? Will more than two crewmembers rotate through the stacker and machine operator jobs?

Speed of the machine. How fast will the machine creep down the field? More important, who decides? When workers at one firm expressed concern about an externally determined pace, management turned over full control to the crew itself. No problems in achieving crew consensus or covering normal acreage have ensued.

Pay rates. What share of efficiency gains will be allocated to compensate for the increased volume of berry handling and to raise individual worker earnings? How much will pay be based on time and how much on output? What is a fair relationship between old and new piece rates?

Scheduling, rest breaks, and safety training. Are adjustments needed to explain or alleviate possible ergonomic risks of increased picking time?

Introduction of the new system itself. When and how will workers be informed about the machine system and the changes around it? Will they have a choice of working in a traditional or a machine-aided crew? One firm offered that choice to employees upon their recall or hiring this year. It guaranteed that machine crew earnings would be no less than in traditional crews, and it offered a cash bonus for completing the season in a machine crew.

Answers to these questions could spell the difference between a smooth and rocky adoption of the new technology. In time, worker responses may drive grower decisions about using the machine, because humans make the strawberry production system run or not. As one grower recently told his business partners: "Without the skilled people who work for us out there, we're nothing."

For More Information

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