High density orchards facilitate harvest

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Decisions regarding high, medium, or low density orchards must include consideration of present and future mechanization. Tree size, shape, spacing, and pruning methods in established orchards limit the selection of new methods for performing cultural and harvest operations. Every effort should be made to plant and train new orchards so as to make them as adaptable as possible to new technology but also suited to present methods. Many tree crops will be harvested by hand labor for some time; yet we cannot afford to invest in new plantings without considering mechanization. The wisest plan is to consider hand operations now and mechanized operations in the future.

Conventional rootstocks at conventional spacings do not produce optimal apple and pear trees for either hand labor or mechanization. Workers prefer smaller trees, and mechanization is not easily adapted to conventional orchards. Thus, high or medium density orchards are preferable.

Labor-intensive activities, such as pruning, thinning, and harvesting, must be well planned. Productivity of workers can be increased through some form of mechanization or by developing a well-defined work pattern, possibly using a labor aid to organize activities.

Making hand labor more productive

Productivity of hand labor can be increased by high-yielding trees and hedgerow-type orchards, such as are used in Italy (fig. 1); by shorter trees (fig. 2); and by trees that bear uniformly.

On high-yielding trees, workers spend more time actually removing fruit. Hedgerow-type (palmetta) orchards cut down random movement of pickers about the orchard, and encourage an organized work routine. With shorter trees, more fruit can be picked from the ground and less time is spent moving ladders—which takes about one-third of the pickers' time on mature, standard-size apple trees. A uniform fruiting zone along the row, uniform bearing from top to bottom and on opposite sides of the trees, and uniform fruit maturity all improve worker productivity.

Researchers in England found that picking rates were 80 percent higher when fruits were distributed uniformly rather than irregularly. Picking citrus from the ground with a short reach is 1.3 times as fast as from the ground with a long reach or from a ladder with a short reach, and 1.8 times as fast as picking on a ladder with a long reach.

Platforms increase worker productivity in pruning, but are not always helpful for harvesting. In pruning, they are used for a long period of time, which increases the benefits in relation to costs. The platform engine provides a convenient source of power, so workers can use power pruning equipment. Figure 1 illustrates the increased picking rate observed by Italian researchers when platforms were used. In the United States, relatively inexperienced pickers have been aided by platforms.

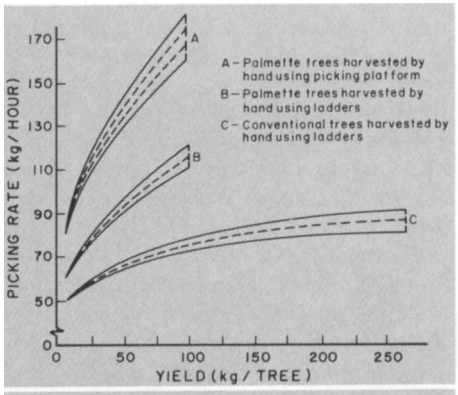

Fig. 1. Effect of yield and orchard system on picking rate. (Based on work in Italy by A. Antonietti and M. Grillenzoni.)

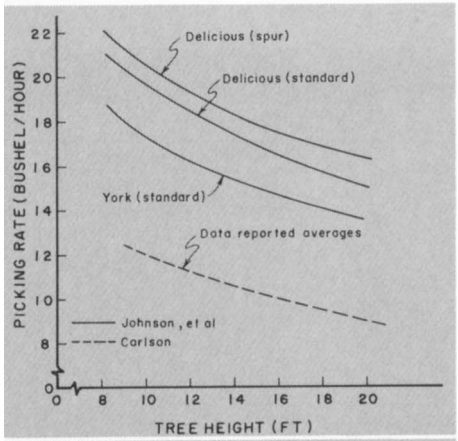

Fig. 2. Effect of tree height on picking rate for hand harvest. (Based on work by R.B. Carlson in Michigan and by J.M. Johnson, G.R. Williams, and R.E. Byers in Virginia.)

Most researchers have found that using the techniques discussed here realistically can increase picking rate about 20 percent for relatively inexperienced workers. Experienced workers who are being paid piece rates have usually organized their work pattern and already pick at their top speed.

Planning for mechanization

Mechanization of orchard operations requires trees of uniform size and fruiting area. Mechanical pruning now consists of trimming the top or sides of the trees with circular saws or cutter bars, and then making detailed cuts by hand. This procedure may be limited, but it does provide uniformity of size and shape.

Tree shakers, supplemented with hand labor, might be used for mechanical thinning. Reasonable distribution of fruits by this method requires that trees be trained so that a shake can be uniformly delivered to all fruiting branches.

In spraying, which is essential to orchard management, uniform distribution of chemicals requires both correctly designed equipment and good exposure of all fruiting wood, such as is provided by a hedgerow-type orchard.

Harvest

The harvest operation is often considered to have the greatest labor requirements and the greatest potential for mechanization. Here, too, the basic principle is to plan an orchard with uniform trees that can accommodate machines.

Researchers have tried many mechanical means of removing fruits from trees. Thus far, shaking trees to detach fruits is the only method that has received commercial acceptance. Three common forms of shaking are: (1) mechanical shakers, which shake primary branches or the trunk of the tree, (2) pulsating air blowers, which shake the foliage, and (3) canopy shakers, which clamp peripheral foliage and shake the fruiting branches.

Mechanical shakers are the machines most commonly used for fruit removal. In general, growers and manufacturers have found that trunk shaking

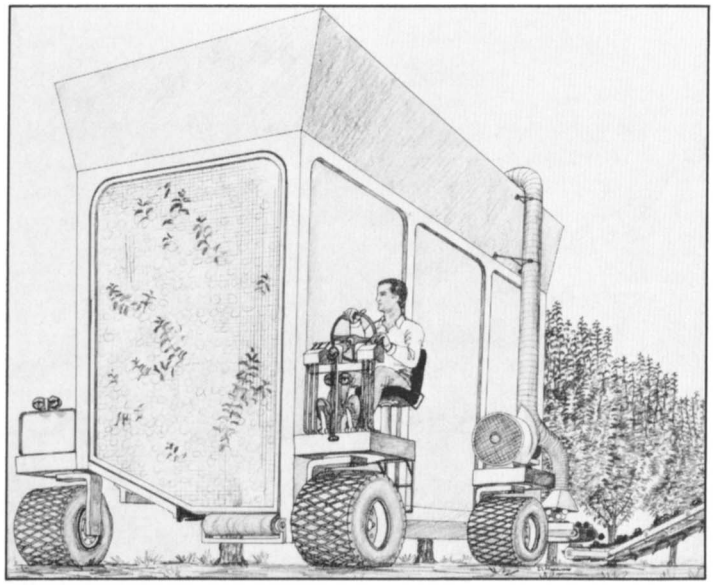

Fig. 3. Schematic of experimental mechanical harvest system that uses plastic balls to slow the fall of fruits. (Based on work by A.G. Berlage and R.D. Langmo in Washington.)

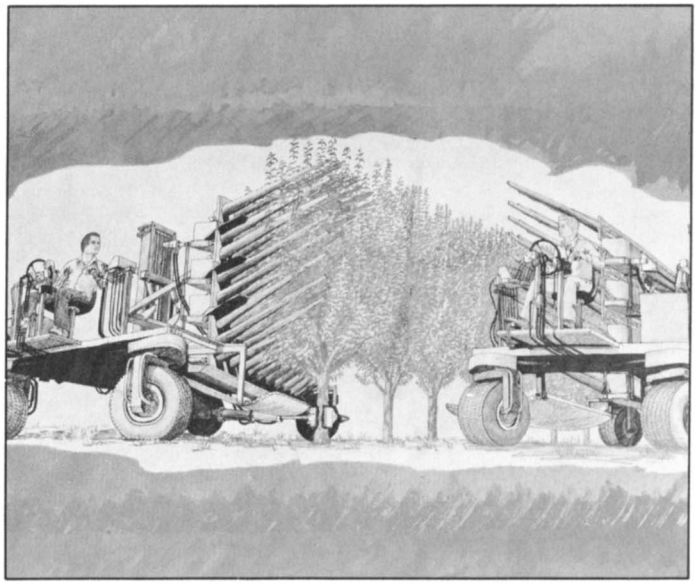

Fig. 4. Schematic of experimental collector-decelerator harvester that slows the fall of detached fruits and directs them to the periphery of the tree.

is fast, easy, and effective, and have preferred trunk shakers to limb shakers. Based on this success, it would be shortsighted to train an orchard that is not adaptable to trunk shaking.

The trunk should be at least 20 inches high, and the entire tree structure should be stiff and without long hanger branches. If the trees have three or four primary scaffolds, limb shaking can be used also. The fruiting zone should be near the tree periphery to allow for the possibility of shaking fruiting branches.

Carefully designed equipment and properly trained trees are essential if fruits are to be undamaged during collection. All hard catch surfaces should be padded. Conveyers and other areas where fruits collect should have decelerator strips, and cover fabrics should be "dead," so that fruits do not rebound into other falling fruits.

Harvest trials with several stone fruits have shown that, when catching frames are well designed, most fruit damage is caused by the tree—either by vibrating limbs hitting fruit before or during detachment or by falling fruit hitting limbs. Shorter trees and carefully pruned major scaffold branches within the tree minimize bruises caused by fruits hitting limbs. For example, peach trees have been trained into the form of a vase using three or four primary branches, each divided into secondary branches, which together form a single inverted cone or vase shape. Some fruits, particularly pears and apples, pose a difficult challenge, because they are highly susceptible to damage, and the trees have a naturally upright growth habit. Here, new approaches to machine design and tree training are essential.

Research

Research in training trees into a multilevel or plateau shape and collecting fruits by a multilevel catching frame has met with limited success. An alternate approach has been to insert a multilevel catch surface into the tree to reduce drop height. Training trees into a Y-shaped tree wall to allow relatively free fall of fruits from the tree is currently being evaluated. Padding limbs seems to be of limited practical value.

Positioning fruit-size, soft, plastic balls within the tree to slow the descent of detached fruits (fig. 3) has minimized damage but impaired fruit removal.

A collector-decelerator machine developed at the University of California, Davis, consists of a panel with inflated tubes inclined at a 40° angle extending into the tree (*California Agriculture*, March 1977 and June 1974). The tubes decelerate falling fruits and divert them to collection conveyors at the perifery of the tree (fig. 4). Results have been encouraging on hedgerowed pears and apples.

The most commercially acceptable means of mechanical collection is not certain; however, fruits produced near the tree surface are likely to be most easily harvested without excessive damage.

Conclusion

In planting new orchards, growers are faced with the dilemma of what trees to plant, what spacings to use, and how to train the trees. It is wise to give serious consideration to current and future mechanization potential in making these decisions. Although our crystal ball is not sufficiently clear to make the answer simple, good judgment can provide trees that are productive in the short range and adaptable to mechanization in the long range.

High density orchards with relatively small trees have good potential for future mechanization. Considering future harvest and thinning operations, trees should be trained with sufficient trunk height and pruned to develop a stiff structure to permit possible future use of trunk shakers. The trees should not be bushy, and fruit should be concentrated near the outside of the tree. Trees should also be relatively uniform in shape and size.

Spacing is not critical, but space between rows should be sufficient to allow easy access for either hand crews or machines. Within the row, spacing should be close enough to form a continuous fruiting wall or at least approximate a continuous wall with close-spaced trees.

Dreaming a little, another possibility for the future is ultra-high-density plantings, which have excellent prospects for future mechanization. However, we are not yet far enough along to know their full potential or problems.

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