

Mechanical Harvesting and Vineyard Mechanization

WEbg 1994:4,11,13-19.21-23 1994

by Justin R. Morris

The ever-increasing shortage and cost of qualified labor have made vineyard mechanization more important for viticulturists. Extensive research over the years has made mechanical harvesting feasible, but it is now known that mechanical harvesting works best when a total system of trellising, pruning, shoot positioning, and canopy management has been implemented. The pruning and shoot positioning operations that are currently being mechanized are resulting in totally mechanized

production and harvesting systems. Moreover, the use of integrated pruning techniques, cultural programs, and harvesting methods are becoming increasingly common today. Grapevines are modified by various trellising and pruning methods so that production can be successfully mechanized.

The initial impetus to develop mechanization of labor intensive crops in the United States came from manpower shortages during World War II and similar shortages during the Korean conflict. Then, in December of 1964, the United States terminated the Bracero Program which had allowed the admission of thousands of Mexican

workers into the country for agricultural labor purposes. This action pointed up the need for alternative mechanical harvesting methods that were both labor and cost efficient.

Experimental mechanical harvesting of processing grapes began in California in 1952 when a cutter bar, head harvester was used on grapes trained for this purpose. This system did not prove to be commercially acceptable. During the 1960s, the Cornell Grape Harvester, which was a spiked wheel shaker, was perfected for continuous operation with automatic positioning in an over-the-row experimental machine. The Chisholm-Ryder Company built a commercial version of the Cornell Grape Harvester, and a modification of this machine led to the first commercial grape harvester, which was built in 1963. In 1965 this design was modified further into an over-the-row machine for Geneva Double-Curtain-trained vineyards. Continued refinements were made for two production models which were built for the 1967 harvest season.

During this same period, growers Max and Roy Orton of Ripley, New York, were developing a horizontal-action machine that would harvest conventional single-curtain-trellised vines. The Chisholm-Ryder Company built the prototype of the Orton machine for the 1967 season (Figure 1). It became the most widely used grape harvester in the eastern United States for single curtain vineyards. Another earlier



Photo courtesy of the University of Arkansas

Figure 1. One of the first commercial Chisholm-Ryder units that was perfected from Orton prototype.

version of a mechanical harvester is shown in Figure 2. Twenty-six horizontal-action machines and four of the Geneva Double Curtain machines were used during the 1968 season.

The current grape harvesters used in the United States are over-the-row machines that shake berries and/or clusters from specially pruned and trellised vines, catch them, and transfer them to bulk containers in adjacent rows. Today, many of the commercial harvesters in California grape growing regions employ "pivotal strikers," which consist of a double bank of flexible horizontal rods that strike and shake the vine to remove fruit. The "trunk shaker" or pulsator harvesting concept is another method commonly used in California (Figure 3).



Photo by Hudson Cattell (Pennsylvania Grape Letter and Wine News)

Figure 2. The CMH Harvester, a side-mounted over-the-row unit, was developed in 1976 by the CMH Manufacturing Company in North East, Pennsylvania.



Photo courtesy of American Grape Harvesters

Figure 3. The trunk shaker tits inside an over-the-row harvester and works best on bilateral cordon-trained, spur-pruned vines where each vine is individually staked.

This method incorporates two parallel rails to impart horizontal vibration to the upper trunk and/or cordon. The trunk shaker is most effective in removing fruit located close to a rigid trunk or cordon, and much less material other than grapes is harvested. Although trunk shakers are widely used in California vineyards, very few if any vineyards in the eastern United States have been designed for this type of harvester.

Some machines have combined the two principles and reduced the number of horizontal rods. One commercial company refers to its unit as a "pivotal pulsator." This unit reduces harvest of material other than grapes and vine damage since it operates at a low speed. A harvester with a "pivotal striker" head has more tolerance for handling stakes that may be out of line than the "pulsator" head. The "pulsator" can put tremendous pressure on stakes if the machine deviates from the row center. Guidance systems can be placed on harvesters to help the operator keep the mechanical harvester centered on the row.

Improvements in harvesting equipment over the years have made possible extensive operations, although adjustments in cultural procedures for growing the grapes and in handling the harvested fruit have been made as needed.

Adaptation in the Vineyard

Culture

It is necessary to modify vines by various training and trellising methods so that pruning, shoot positioning or canopy management, and harvesting operations can be mechanized. With the decreasing availability of qualified labor, it is becoming clear to grape producers that pruning, tying, shoot positioning, leaf removal, and/or canopy management should be the next operations mechanized.

It is impossible to discuss mechanical harvesting or mechanical pruning of grapes without understanding the importance and significance of trellising and training of vines. The ease or difficulty of vineyard mechanization can depend upon vine vigor, training system, and type and condition of the trellis system. The following conditions must be optimized for the successful mechanical harvesting and mechanical pruning of grapes:

1. **Vine Spacing.** Although vine spacing within rows is irrelevant, a minimum of 2.4 meters between vine rows is required to accommodate most mechanical harvesters. Harvesters that are capable of harvesting narrow rows are used commercially in Europe, and a recently modified grape harvester designed and built by a commercial grape grower in New York has the capability of harvesting 1.2 meter rows.

2. **Vine Height.** Vine height gives the most flexibility to the setting of the harvester's shaking mechanism for more efficient harvesting. The optimum height is dependent upon the harvester used.

3. **Vine and Row Alignment.** Any vines or grape stakes out of alignment will slow the rate of harvesting. Straight rows and trunks are equally critical for other mechanized operations such as pruning and shoot positioning.

4. **Vine Row Obstructions.** If a totally clear vineyard site is not possible, it is necessary to do some advance planning to circumvent obstructions.

5. **Soil Conditions.** Wet soil can slow or stop harvesting, and uneven surfaces can cause the harvester to damage vines.

6. **Removal of Metallic Debris.** In mechanically harvested vineyards trellised on wooden stakes, it is imperative to install a magnet on the machine's discharge conveyor to collect stray staples and other metal

objects. These objects can cause extensive damage to processing equipment if allowed to get that far.

7. **Vine Trellis.** The trellis system must be designed for maximum harvest efficiency for a given cultivar and mechanical harvester. Traditionally, grapevines have been trained to provide a support system for production. However, these systems are not necessarily suited to mechanization. Trellis systems must be designed and shoots positioned to accommodate precise mechanical movement to use machines successfully for pruning, harvesting, and other grape production operations. The morphological characteristics of different cultivars can also influence the system required. Poor trellis design and training of vines can be major contributors to a high percentage of material other than grapes such as bark, cane, leaves, and petioles.

Trellis System Mechanization

Many of the single-curtain training systems (Four-Arm Kniffin, Umbrella Kniffin, Keuka High Renewal, and other long, canepuning systems) are effective for mechanical harvesting but impossible for mechanical pruning. To totally mechanize a vineyard, the trellis system must be designed to allow maximum accessibility of the fruit to the shaking mechanism of the harvester and to allow effective mechanical shoot positioning and pruning. A properly trained vine allows efficient machine operations without excessive damage to the vines or reduction of fruit yield and/or quality.

The Geneva Double Curtain Training System developed by Nelson Shaulis and others in 1966 accomplished these objectives. The Geneva Double Curtain trellis system doubles the length of the cordon per vine and, when used in conjunction with shoot positioning, increases the number of shoots that have basal nodes exposed to sunlight. Vigorous vines of large-leafed labrusca cultivars, which have a drooping-shoot growth habit and annual cane prunings of 1.35 kg or more, give the greatest response to the Geneva Double Curtain system.

The Geneva Double Curtain trellising system requires a three-wire trellis with two horizontal cordon support wires and a single trunk support wire. The flexible crossarms allow for mechanical harvesting. The cordon-support wires should be 180 cm above the ground and 120 cm

apart. The vines are cordon trained and short-cane pruned (i.e., 4 to 6 nodes).

In contrast to vinifera, the fruiting canes of labrusca cordon-trained vines are selected from the lower 180° of the horizontal cordon. The cordon must be in continuous contact with the support wire to obtain maximum efficiency from mechanical harvesting and pruning.

Bilateral cordon-trained labrusca vines also can be effectively pruned and harvested by machine. The Bilateral Cordon trellis system for Eastern-grown labrusca consists of establishing bilateral cordons on 8-gauge, high-tensile-strength steel wire at about 180 cm above the vineyard floor. The fruiting canes are selected as described for the Geneva Double Curtain system.

Researchers in Arkansas compared the three major trellis systems and found the Bilateral Cordon system to be as productive as and to produce fruit quality comparable to that of the Umbrella Kniffin system. All of the single curtain types of trellising systems (such as the Bilateral Cordon, Umbrella Kniffin, Hudson River, and 4-cane Kniffin) can be mechanically harvested. However, it has been shown that the Geneva Double Curtain system is more productive than any of the other systems with no reduction in fruit quality. Of the systems evaluated, only the Bilateral Cordon and Geneva Double Curtain systems can be effectively harvested, shoot positioned, and pruned mechanically.

Even with all of the advantages of the cordon systems, there are still problems such as cordons that sag or break loose from the wire. The action of the mechanical harvester may cause damage if the vines slide along the cordon. This type of damage causes a large number of cut surfaces and may increase *Eutypa lata* fungus infections. A cordon system will increase the chance of infection by *Eutypa* in any event since it uses spur pruning. In addition, harvester damage may contribute to winter injury on tender cultivars in areas where winter injury is a problem.

Bilateral Cordon training with spur pruning is currently a common

system in California. Since vinifera cultivars grow upright, the fruiting spurs are selected from the upper 180° of the cordon. A common Bilateral Cordon trellis used for California wine grapes consists of a two-wire vertical trellis. A 210 cm stake is driven into the ground to a depth of 50 cm at each vine. A 12-gauge, high-tensile-strength cordon wire is located about 105 cm above the vineyard floor. A foliage support wire (13-gauge) is usually attached 30 cm above the cordon wire. This wire is moved upward for better foliage support as the spur positions move upward with age. For extremely vigorous vines, some growers install a third wire at the top of the stake for additional support, and some growers install a cross arm on top of the stake to spread two top wires 72 cm to 90 cm. The width of the cross arm is determined by vine vigor and by the choice of mechanical harvester. The distance between the fruiting wire and the cross arm is a compromise between maximum foliage support, accessibility of harvester rods, and the anticipated increase in spur length.

In a six-year trellis trial at the Kearney Agricultural Center in Parlier, California, higher yield was produced from Bilateral Cordon vines on a one-wire trellis at approximately 170 cm than from vines trained to the traditional trellis with foliage support wires as described in the previous paragraph. The higher yields were attributed to increased cluster numbers thought to be the result of better light exposure of the lower buds.

Currently, some vineyards in Napa, Sonoma, and the North Coast wine regions are establishing or testing elaborate trellis systems that will allow maximum yields and sunlight exposure in extremely vigorous and/or high density vineyards. Most of these new systems cannot be mechanized with today's technology.

On the theory that winter pruning disturbs the vines' natural process of self regulation of growth and production, a trellising system has been developed by researchers in Australia that requires minimal pruning and provides ideal vine

information for mechanical harvesting. This system is called the Minimal Pruning of Cordon-Trained Vines. Cordon-trained vines are trained to either a single or double high wire in the vertical plane. Pruning is done either in winter or summer and consists of skirting at the sides. The cordons and canes grow into a large permanent canopy over the seasons. Skirting can be accomplished with simple and inexpensive tractor mounted equipment. Commercial gains in yields have been realized with this trellising system. The Minimal Pruning system of producing grapes can be successfully mechanically harvested. This system is currently receiving extensive evaluation by Robert Pool and others at the New York State Agricultural Experiment Station.

Mechanical Pruning

Research initiated in 1968 in Arkansas indicated that mechanical pruning could be accomplished and would reduce hand labor by as much as 50%. Two viticultural concerns were addressed in these early research studies. First, it was impossible to

treat each vine individually. Since balance pruning according to vine size is the customary method of pruning the labrusca, this method would result in the overcropping or undercropping of individual vines. Second, it was impossible to select and leave only the best fruiting canes since the mechanical pruner did not discriminate between canes.

Proper shoot positioning, which can be accomplished mechanically, has helped eliminate this second concern. It allows a high percentage of canes to be productive by maximizing sunlight exposure to all canes.

Other Arkansas studies have examined the effects of mechanical pruning on yield, vine size, and juice quality of shoot-positioned Concord grapevines on Geneva Double Curtain or Bilateral Cordon training systems. In these studies the vines were mechanically pruned or balance pruned to a 30+10 severity. The mechanically pruned vines were either left untouched (no touch-up) or adjusted to 60 or 90 nodes per vine. In a six-year study of mechanized pruning, vines that were adjusted to the best 60 nodes by follow-up hand pruning maintained vine size and produced fruit yield and juice



Photo courtesy of the University of Arkansas

Figure 4. This photo shows a Slawson Mead pruner operating in a research vineyard at the University of Arkansas on a Bilateral Cordon trained system that has been mechanically shoot positioned.

quality comparable to vines balance pruned to a 30 + 10 level. Both the no touch-up treatment and retaining 90 nodes per vine following mechanical pruning treatment reduced per-vine and per-node fruit yields during the sixth year (which had both heat and drought stress conditions) and resulted in unacceptable juice chemistry and sensory juice quality. Also, these two treatments resulted in uneven ripening of Concord grapes under Arkansas conditions, which contributed to the problem of low soluble solids and poor juice color. The results showed that continuous mechanical pruning of Concord grapes under Arkansas conditions is recommended only in shoot-positioned vineyards where pruning can be followed by cane selection and adequate node limitation, and where adequate irrigation water is available.

A mechanical pruning aid for Concord grapes was developed in New York in 1977 for use on cordon-trained vines. A triangular arrangement of reciprocating cutter bars established the length of cane and cane position (Figure 4). This New York pruning system was supplemented by a mechanized brushing technique to remove the top shoots (upper 180° of the cordon) early in the spring. With these techniques, vines were mechanically pruned successfully with no manual selection of canes for one season. This system can be successfully implemented with the Geneva Double Curtain harvester. In Australia, studies were made of mechanical hedge pruning of Cabernet Sauvignon and Doradillo vines that were trained to a Bilateral Cordon system. The following hedge shapes were established in that study:

- 1) A square hedge with three cutting planes that produced a square cross section (the distance from the cutting plane to the cordon was set to give node numbers that were similar to the controls),
- 2) an offset rectangular hedge in which the vines were trimmed close to the cordon on one side during alternate years to allow for new spurs to develop, and

- 3) a hedge pruned to a triangular shape on the upper 180° portion of the cordon.

The yield and capacity of hedged vines were equal to or greater than those of the manually pruned vines, except in 1976 when the hedged Doradillo vines had lower yields. With Cabernet Sauvignon, a triangular hedge initially had lower yields than the square and offset hedges, but in later years, it yielded more than the square and offset hedges. This increase in Cabernet yield with the triangular hedge was a result of increased berry number compared to the other hedge shapes. The conclusion was that mechanical vine hedging was a viable alternative to detailed manual pruning for these vinifera grapes in Australia.

In another study in Australia, it was found that the major quality characteristics affected by total mechanical pruning were small berries and small clusters. Also, the mechanically pruned hedge presented no problem during the mechanical harvesting operation. Mechanical hedging of vinifera vines on a commercial scale is rapidly being adopted in Australia, and all of these systems can be successfully harvested mechanically.

In Italy it has been reported that alternate "up-down" mechanical pruning of Geneva Double Curtain-trained vinifera grapes in Bologna gave satisfactory results in production and vegetative response of the vines for a three-year period. Four years of tests and surveys have led to the conclusion that, for mechanical pruning to be practical, it is necessary to control the bud load annually. Further, mechanical pruning must ensure an adequate number of renewal canes with short cuts on some parts of the cordon to avoid the premature aging of the vine. In general, however, vines of selected vinifera grew better than expected and had better fruit quality after being mechanically pruned. Some commercial operations in California use mechanical pruners hung from the inside chassis of a grape harvester. One such

commercially available unit is composed of a shredder, four side cutters, and two top cutters.

The shredder eliminates the major portion of canes on the sides and lower portions of the cordon. The side cutters are automatically centered on the vine row and cordon by guidance skis. The top cutting saws can be hydraulically adjusted by an operator to maintain the desired vertical length of spurs above the cordon. It is critical to have well-managed, uniformly trained cordons in order for this unit to operate at maximum efficiency.

In Italy machinery is available for other viticultural operations, e.g., deshooking, topping and hedging of shoots, positioning and tying of shoots, and defoliating.

Mechanical Shoot Positioning

Effective mechanical pruning with labrusca species produced on the Geneva Double Curtain or Bilateral Cordon systems can be accomplished only when the vines are shoot positioned. Shoot positioning improves fruit quality and exposes the basal nodes on the bearing units to sunlight and makes them more productive. It is particularly effective with large, vigorous vines of labrusca cultivars that have large leaves and a drooping-shoot growth habit. While it is possible to shoot position by hand, it is more efficiently done by a mechanical shoot positioner. A new shoot positioner developed by Tommy Oldridge, an Arkansas grape producer, is an improvement over other machines for positioning Geneva Double Curtain-trained vines (Figure 5). Vines are usually shoot positioned for the first time just before bloom. Complete shoot positioning usually requires a second and sometimes a third pass with a mechanical shoot positioner. If the Arkansas Geneva Double Curtain brush attachment is used, the vigorous shoots growing between the two cordon wires will be pulled or knocked down to maintain two separate foliage canopies. This division also can be accomplished to a lesser extent by using a weighted bar or a large plastic-coated chain, which is pulled through the center of the divided cordons.



Photo by Hudson Cattell (Wine East)

Figure 5. The Oldridge unit is mounted under a Chisholm-Ryder harvester that is designed to position Double Curtain vineyards. Photo taken at Roy Orton's vineyard, Ripley, NY.

A properly shoot-positioned Geneva Double Curtain system with two separate foliage canopies is more efficient to harvest than a nonpositioned canopy. A bilateral or single curtain system that has been shoot positioned also is easier to mechanical harvest with less damage to fruit and canes.

Cultivar Effect on Mechanical Harvesting

Cluster morphology, the adherence of berries to clusters and the adherence of clusters to vines, is the main factor that determines how easily and in what condition the fruit is removed. The fruit of most cultivars is removed primarily as single berries, particularly those of cultivars with loose attachment. Cultivars with a firm berry attachment and a tough or wiry cluster framework are the most difficult to harvest mechanically. Emerald Riesling, for example, has berries that are held securely by the internal vascular system ("brush") of the pedicels.

Most harvesters will "juice" the fruit off the vine, leaving the cluster framework and the large, wet brushes behind. The soft, juice berry texture of Semillon, Muscat Canelli, and Burger presents harvesting problems because of juice loss during fruit handling. Conversely, the firm berries of easily harvested Tokay and White Malaga undergo almost no juicing during machine removal.

Muscadines

Muscadine grapes (*Vitis rotundifolia* Michx) present a different problem for mechanical harvesting. Most muscadine cultivars do not ripen uniformly and once-over mechanical harvesting removes immature as well as mature berries. The presence of immature fruit is undesirable since it lowers the quality of the processed product. Development of new cultivars in which all berries ripen uniformly would be a major advantage for the mechanical harvesting of this species of grape.

The University of Arkansas has developed a system for sorting mechanically harvested muscadine grapes into maturity classes that utilizes brine solutions of different strengths to separate grapes according to specific gravity. Thus, ripe berries with good quality can be separated rapidly and inexpensively from immature berries with poor quality. The less mature fruits make the best wine, and the more-mature fruits make the best juice products. Muscadine grapes are also unique in that an abscission layer forms as the berries mature. This layer is so complete within some cultivars that fully ripe fruit will drop in advance of the mechanical harvester's collecting mechanism. To prevent the loss of this over-mature fruit, an extended collecting unit has been designed which is adaptable to the front of any conventional commercial harvester.

Post Harvest Handling

Harvest Mechanization Effects on Quality

Collecting and transporting a high percentage of the yield to processors is economically important, but it is also essential to maintain the quality of the harvested grapes. Conditions that affect quality during harvesting, handling, transporting, and processing include: environmental conditions, cultivar, cultural practices, chemical harvesting aids, material other than grapes, and physical transfer of the grapes to the processor. Mechanically harvested grapes can be of higher quality than hand-harvested grapes when all these influences are considered and when the grapes are delivered promptly to the processing unit. Although many processing grapes can be mechanically harvested, there are still several problems that lead to quality loss.

Machine Effects

Many commercial grape harvesters employ "pivotal strikers" or "pulsator" harvesting units. The shorter the stroke lengths the more damage there is to the grapes, but the frequency of the beater does not affect the amount of damage.

With all harvesting methods, grapes are recovered as cluster parts or individually torn berries. The major quality problem with mechanically harvested grapes is fruit damage from the beater rods or slappers and the handling required after harvest. The percentage of intact, mechanically harvested berries is as low as 40%.

Mechanically harvested grapes may contain a rather high percentage of material other than grapes such as bark, cane, leaves, and petioles. All of this material may not be removed and eventually may reach the processed products. Cultivars that are more difficult to harvest usually contain more material other than grapes than do easily harvested cultivars. Material other than grapes may be reduced by cultural practices or by improved cleaning machinery.

Effects of Time and Temperature

Long delays between mechanical harvesting and delivery to the processing plant can result in increased enzymatic activity and browning, oxidation (i.e., loss of color), development of off-flavors, and microbial growth. Further, the temperature from the time of harvest to the time of processing probably influences the quality of mechanically harvested grapes more than any other factor.

The temperature of the grapes at harvest determines the storage temperature, regardless of the external air temperature. A high grape temperature at harvest combined with a delay in processing leads to rapid deterioration of grape juice quality. At a high fruit temperature of 35°C, grapes have poor color and produce high levels of alcohol and acetic acid, both of which are signs of microbial spoilage. The alcohol and acetic acid contents of mechanically harvested grapes begin to accumulate 12 hours from the time of harvest if the grape temperature at harvest is as high as 29°C and increase rapidly after 18 hours of holding at 29°C or 24 hours at 24°C. Decreases in soluble solids, flavor, and color quality parallel the increases in alcohol and acetic acid content. Off-flavors in the processed juice product can be expected when the alcohol levels reach 0.25%.

Because of the problems associated with excessive heat and quality deterioration, grapes in hot areas such as the San Joaquin Valley of California and the southern United States should be harvested during cool periods of the day or night to minimize quality loss.

The addition of SO₂ to mechanically-harvested grapes immediately after harvest has been shown to slow post-harvest deterioration for 24 hours when held at 35°C by delaying alcohol accumulation and the loss of soluble solids. SO₂ discourages bacterial spoilage and also serves as an anti-oxidant to prevent juice browning. Applied at the concentration of 100 ppm to mechanically harvested juice grapes that were at a temperature of 24°C, SO₂ resulted in a delay of alcohol production for up to 24 hours. The SO₂ application can be made directly on the harvester prior to the fruit being conveyed into the bulk bins, or at an in-field stemmer-crusher.

Handling Systems

The types of containers used for hauling grapes to the processing unit can influence product quality. Initially, 0.91 ton capacity wooden bins with food-grade plastic liners were used to accommodate the fruit. Many operations on the West Coast, however, have shifted to a 3.6 and 4.5 ton capacity hydraulic, self-dumping, metal vineyard gondola that dumps the harvested grapes from the vineyard into bulk tank trucks, which are hydraulically dumped at the processing plant. These bulk collection units do not reduce the quality of the processed product.

In a few commercial operations, the grapes are crushed in the field and transported to the processing unit as soon as the fruit is discharged from the harvester. A closed gondola tank for collecting crushed grapes and juice from the harvester and stemmer-crusher has been developed. This system is effective in controlling microbial growth and oxidation since it permits the injection of CO₂ or N and SO₂ into the tank.

Cost and convenience of the various hauling systems have been

major contributing factors in determining the system selected by a given processor. Additional research, however, is needed in this area.

Guidelines for Mechanized Harvesting and Handling of Wine and Juice Grapes

The following nine guidelines for quality standards were developed at the University of Arkansas in cooperation with commercial grape processors to maintain or improve the quality of mechanically-harvested grapes:

- 1) Select the proper rpm for the shaking mechanisms or strikers and the proper ground speed for the harvester for each cultivar and crop load situation. The importance of proper machine adjustments and operation cannot be overemphasized.
- 2) Establish a time limitation from harvesting to processing plant delivery. The time limitation will depend upon the cultivar (2 to 4 hours for grapes used for premium white wines and 8 to 14 hours for grapes used for red wine and grape juice).
- 3) Optimize fruit temperature and SO₂ usage. The SO₂ should be applied, when harvesting under high temperature conditions, at the rate of 50 to 100 ppm as the grapes pass over the final delivery conveyor.
- 4) Eliminate problems of material other than grapes. This may require the mechanical trimming of low-hanging canes that interfere with harvest, removing bird nests and tall weeds, and preparing a smooth surface on the vineyard floor.
- 5) Cease cultivation sufficiently prior to harvest to minimize dusty conditions during harvesting.
- 6) Inspect the vineyard for foliar-feeding insects and, if necessary, apply sprays sufficiently ahead of harvest.
- 7) Provide a bin or conveyor inspector as part of the harvesting crew. This individual would remove material other than grapes; watch for plugging of cleaning fans, hydraulic leaks, and mechanical failures; and monitor the application of SO₂.
- 8) Cover harvested grapes at all times. Also, delivery bins or containers

must be properly cleaned after the grapes are dumped at the processing plant or winery.

9) Clean mechanical harvesters thoroughly with an approved detergent-sanitizer as needed or at least at the end of each 8 to 10 hour operating shift (under some conditions a complete high-pressure water rinse may be required during the operating shift).

Potential for the Future

The mechanization of wine and juice grapes is the most successful, most advanced, and most complete of any system currently in use to harvest fruit crops. Additional research is needed, however, in all of the areas to improve quality of mechanically-harvested grapes. Requirements for maintenance of quality mechanically-harvested grapes should be developed for each of the major production regions since regional requirements may differ.

Research that could change traditional viticulture in the Eastern United States is being conducted in New York by Robert Pool and others. These studies include no-till viticulture in nonirrigated vineyards. With the need for cultivation overcome, reduced row and vine spacings (1.2 and 1.4 meter rows vs. 2.4 meter rows) will require over-the-row machinery modification to mechanically prune and apply fertilizers, herbicides, and pesticides. The experiments are well established, and yields are encouraging. Narrow-row harvesters are currently available in Europe that are equipped with transverse leveling systems for problem terrains and hydraulic receiving and dumping tanks located immediately behind each conveyor and cleaning fan.

An active research program being conducted by the author on total vineyard mechanization has been underway at the University of Arkansas since 1968. In one study established in 1982, treatments have not received any hand labor after vineyard establishment (first three years). This Geneva Double Curtain vineyard has received total mechanization for eight consecutive years. Mechanization has included

shoot positioning, pruning, and thinning. The objective of this research is to determine the extent to which all viticultural operations can be mechanized using the Geneva Double Curtain trellis system without any loss of final product quality. Additional research and development must continue with emphasis on development of totally integrated production and harvesting systems and the provision for less damage, more selectivity, and less debris.

References

- Bourne, M.C., D.E. Splittstoesser, L.R. Mattick, W.B. Robinson, J.C. Moyer, N.J. Shaulis, and E.S. Shepardson. "Product Quality and Mechanical Grape Harvesting." Proc. New York State Hort. Soc., Geneva, N.Y., 1963.
- Cargill, B.F. and D.E. Booster. "Vibration Removal Techniques: High-Density Applications." In: O'Brien, M., B.F. Cargill, and R.B. Fridley (eds.), Principles and Practices for Harvesting and Handling Fruits and Nuts. AVI Pub. Co., Inc., Westport, Ct., 1983, p. 189-219.
- Cargnello, G. "Research on New Training Systems and on Total Mechanization of Viticultural Operations." In: UCD Grape and Wine Centennial Symposium Proc. Univ. Calif., Davis, 1980, p. 274-283.
- Christensen, L.P., A.N. Kasimatis, J.J. Kissler, F. Jensen, and D.A. Luvisi. "Mechanical Harvesting of Grapes for the Winery." Calif. Agri. Exten. Bull. AXT-403, 1973.
- Clingeffer, P.R. and J.V. Possingham. "The Role of Minimal Pruning of Cordon-Trained Vines (MPCT) in Canopy Management and Its Adoption in Australian Viticulture." Australian Grapegrower and Winemaker 283, 1987, p. 17-23.
- Freeman, B.M. "Experiments on Vine Hedging for Mechanical Pruning." In: UCD Grape and Wine Centennial Symposium Proc. Univ. Calif., Davis, 1980, p. 261-263.
- Fregoni, M., M. Boselli, G. Dorotea, G. Montesani, B. Volpe, and M. Zambom. "The Role of the Permanent Cordon and the Double Curtain in Training Forms Adapted to the Mechanical Harvesting of Grapes." Vignevini 11:10, 1984, p. 19-25.
- Gil Sierra, J. and J. Ortiz-Canavate. "Mechanization Experience with Pruning and Harvesting in Trained Vineyards." Zangosa, Spain: Asociacion Nacional de Ingenieros Agronomos, 1988, p. 293-298.
- Jordan, T.D., R.M. Pool, T.J. Zabadal, and J.P. Tomkins. Cultural Practices for Commercial Vineyards. New York State College of Agri. and Life Sci., Cornell Univ., Ithaca, N.Y., Msc. Bul. 111, 1981.
- Morris, J.R. and D.E. Cawthon. "Mechanical Trimming and Node Adjustment of Cordon-Trained 'Concord' Grapevines." J. Amer. Soc. Hort. Sci. 105:3, 1980, p. 310-313.
- Morris, J.R. and D.E. Cawthon. "Yield and Quality Response of 'Concord' Grapes to Training Systems and Pruning Severity in Arkansas." J. Amer. Soc. Hort. Sci. 105:3, 1980, p. 307-310.
- Morris, J.R. and D.E. Cawthon. "Yield and Quality Response of 'Concord' Grapes (*Vitis labrusca* L.) to Mechanized Vine Pruning." Amer. J. Enol. Vitic. 32, 1981, p. 280-282.
- Morris, J.R., D.E. Cawthon, and J.W. Fleming. "Effect of Mechanical Pruning on Yield and Quality of 'Concord' Grapes." Ark. Farm Res. 24:3, 1975, p. 12.
- Morris, J.R., D.E. Cawthon, and J.W. Fleming. "Effects of Temperature and SO₂ Addition on Quality and Postharvest Behavior of Mechanically-Harvested Juice Grapes in Arkansas." J. Am. Soc. Hort. Sci. 104, 1979, p. 166-169.
- Morris, J.R., J.W. Fleming, R.H. Benedict, and D.R. McCaskill. "Maintaining Juice Quality of 'Concord' Grapes Harvested Mechanically." Ark. Farm Res. 22:1, 1973, p. 3.
- Petrucci, V.E., C.D. Clary, and M. O'Brien. "Grape Harvesting Systems." In: M. O'Brien, B.F. Cargill, and R.B. Fridley (eds.), Principles and Practices for Harvesting and Handling Fruits and Nuts. AVI Pub., Westport, Ct., 1983, p. 525-574.
- Shaulis, N.J., J. Pollock, D. Crowe, and E.S. Shepardson. "Mechanical Pruning of Grapevines; Progress 1968-1972." Proc. New York State Hort. Sci. 118, 1973, p. 61-69.
- Shepardson, F.S., H.E. Studer, N.J. Shaulis, and J.C. Moyer. "Mechanical Grape Harvesting Research at Cornell - III." J. Am. Soc. Agric. Engr. 43:2, 1962, p. 66-71.
- Vannucci, D. "Harvesters for Vineyards in Hilly Areas." Terra a Vita 10, 1987, p. 24-31.

About the Author

Justin R. Morris, University Professor in the Department of Food Science at the University of Arkansas, was recently honored as the 1993 recipient of the Faculty Distinguished Achievement Award for Public Service and Research.

