

MECHANIZING CONCORD VINEYARDS FOR GREATER PROFITS

Justin R. Morris, University of Arkansas, Department of Food Science, Fayetteville, AR 72703

There is a major research effort throughout the world to modify grapevines so that viticultural practices can be economically mechanized while maintaining or improving yield and quality. Trellis systems must be devised and shoots positioned to accommodate precise mechanical movement, to use machines successfully for pruning, harvesting, and other grape production operations.

Trellising systems for mechanization

Many of the single curtain training systems (Four-Arm Kniffin, Umbrella Kniffin, Keuka High Renewal, and various other long cane pruning systems) are effective for mechanical harvesting, but mechanical pruning obviously is impossible with those systems. With the need to improve vineyard management efficiency, there is a need for trellising systems that can be totally mechanized, therefore the trellising system must be designed to allow maximum accessibility of the fruit to the harvester's shaking mechanism and allow effective mechanical pruning. A properly trained vine should allow efficient machine operations without excessive damage to the vines or reductions in yield and/or quality.

One of the first training systems that accomplished these objectives was the Geneva Double Curtain Training System (GDC), developed by Shaulis et al. (22) in New York. The GDC trellising system doubles the length of cordon per vine, and with shoot positioning, there is an increase in the number of shoots on vigorous vines that can have their basal nodes adequately exposed to sunlight. Vines with annual cane prunings of 1.35 kg (3 lbs) or more at 240 cm (8 ft) in-the-row spacing may be expected to give the greatest response to the CDC system (3).

The cordon-support wires should be 180 cm (6 ft) above the ground and 120 cm (4 ft) apart. The vines are cordon trained and short cane pruned (i.e., 4 to 6 nodes). In contrast to *Vitis vinifera*, the fruiting canes of *Vitis labrusca* cordon-trained vines are selected from nodes of very short vertical arms originating within the lower 1800 of the horizontal cordon. The cordon must be in continuous contact with the support wire in order to obtain maximum efficiency from mechanical harvesting and pruning.

Bilateral cordon (BC) trained concord vines also can be effectively harvested and pruned by machine (10,11,12). The BC trellising system for eastern grown Concord consists of establishing bilateral cordons on Basic Brite #8 wire at approximately 180 cm above the vineyard floor. The fruiting canes are selected as described for the CDC system. Research in Arkansas (10) that compared the 3 major trellising systems has shown the BC system to be as productive and to produce comparable fruit quality to the Umbrella Kniffin system; however, the GDC system was more productive than either of the other 2 systems with no reduction in fruit quality. The BC and CDC system can be effective with mechanized harvesting and pruning, hence these systems are recommended for vigorous Concord vineyards.

There are still problems, with all of the advantages of the cordon systems (GDC and BC), such as cordons that sag or break loose completely from the wire. Also, the action of the mechanical harvester, may cause damage if the vines slide along the cordon. This type of damage might increase the amount of *Eutypa* infections. Since it is known that a large number of cut surfaces, which results with spur pruning, the cordon system increases the chance of infection by *Eutypa*. Also, harvester damage might contribute to winter injury in areas where winter injury is a major problem.

Shoot positioning

Effective mechanical pruning can be accomplished with the Concord produced on the GDC or BC system, only when the vines are shoot positioned, which places the canes in proper position for mechanical pruning. Also, shoot positioning is an effective method of improving fruit quality (14) and of exposing the lower nodes on the bearing units to sunlight to make the basal nodes more productive than under shaded conditions (14,22). Shoot positioning is particularly effective with large vigorous vines of Concord. Shoot positioning can be accomplished wither by hand, or, more efficiently, with a mechanical shoot positioner.

As soon as the tendrils touch the wire or another cane, they fasten very quickly, therefore, vines are usually first shoot positioned just before bloom. A good job of shoot positioning will usually require a second and sometimes a third pass with a mechanical shoot positioner.

Mechanical pruning

In the late 1960s, grape producers indicated that once mechanical harvesting was totally implemented, the most time-consuming hand labor operations in the vineyard were the pruning and tying operations. Grape producers complained of decreasing availability of qualified labor for pruning and tying and indicated that these should be the next operation mechanized. (13, 23). A mechanical pruning aid for 'Concord' grapes was developed in New York by Pollock et. Al. (21)

for use on cordon-trained vines. A triangular arrangement of reciprocating cutter bars established the length of cane and cane position. 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 successfully mechanically pruned with no manual selection of canes for one season.

Research was initiated in 1969 in Arkansas, and by 1971, preliminary results indicated mechanical pruning of grape vines could be accomplished and would reduce pruning labor by as much as 50% (13). Two viticultural concerns were pointed out in this early research. One was the impossibility of treating each vine individually (balance pruning according to vine size), which might result in the overcropping or undercropping of individual vines. The other concern was the inability to select and leave only the best fruiting canes since the best canes may be removed by the mechanical pruner. Shoot positioning has helped eliminate this second concern.

An additional detailed study was established in Arkansas to examine the effects of mechanical pruning on yield, vine size and juice quality of shoot-positioned 'Concord' grapevines on GDC or BC training systems (10,12). The vines were mechanically or balance pruned to a 30+10 severity. The mechanically pruned vines were left untouched, or were adjusted to 60 or 90 nodes per vine. After 6 consecutive years, follow-up pruning by hand to limit the number of nodes per vine to 60 following mechanical pruning maintained vine size and produced fruit yield and juice quality comparable to vines balance pruned to a 30+10 schedule. Both the no-touch-up treatment and retaining 90 nodes per vine following mechanical pruning treatments reduced per vine and per node fruit yields after the sixth year and resulted in unacceptable objective and sensory juice quality. Also, these two treatments resulted in uneven ripening of 'Concord' grapes, which contributed to the problem of low soluble solids and poor juice color. Therefore, continuous mechanical pruning of 'Concord' grapes as an aide is recommended only in shoot-positioned vineyards where pruning can be followed by cane selection and adequate node limitation. It was also suggested that grape producers consider a pruning cycle consisting of one year of completely mechanized pruning followed by a year of balanced pruning.

Some commercial operations in California use mechanical pruners mounted to the inside chassis portion 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 the canes on the sides of the vine so that the side cutters can cut the canes on the sides and lower portions of the cordon. These side cutters are automatically centered on the vine row and cordon by the guidance skis. The top cutting saws can be hydraulically adjusted by the rear operator of the pruning unit in order to maintain the desired vertical length of spurs above the cordon. It is extremely critical to have well managed, uniformly trained cordons in order for this unit to operate at maximum efficiency.

Mechanical harvesting

Major developments in juice and wine grape harvest mechanization occurred in the early and mid-1960s (16,24,25,27.), and mechanization was practiced commercially by the late 1960s (2). Mechanically harvested grapes can have better quality than hand-harvested grapes when delivered promptly to the processing unit (28). However, trellising systems continue to be a major prerequisite to successful harvesting of grapes.

Today, many of the commercial harvesters in all 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. This method incorporates two parallel rails to impart horizontal vibration to the upper trunk and/or cordon. The trunk shaker is effective in removing only fruit in contact with a rigid trunk or cordon, and much less material other than grapes (MOG) is harvested. Some of the newer 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 results in less leaf removal and vine damage since it operates at a lower speed. A harvester with a "pivotal striker" head has a little more tolerance for handling stakes that may be out of line than does the "pulsator" head.

Machine-harvested grapes may contain a rather high percentage of MOG such as bark, canes, leaves, and petioles (4,5,20), and poor trellising and training of the vines can be major contributors to this problem. All of this MOG may not be removed and eventually may cause off-flavors in the processed products. Cultivars that are more difficult to harvest usually contain more MOG than do easily harvested cultivars (20). It is also imperative in mechanically harvested vineyards trellised on wooden stakes that a magnet be installed on the machine's discharge conveyor or to collect staples and other iron-containing objects.

Larger fruit and those harvested later in the season are more susceptible to mechanical damage (5,15). The ease or difficulty of mechanical harvest also depends upon training system, type and condition of the trellising system and wire, and vine vigor.

A considerable time delay between mechanical harvesting and delivery to the processing plant can result in increased enzymatic activity and browning, oxidation (i.e., loss of color), and development of off-flavors and microbial growth (1,5,6,18,26). Temperature from the time of harvest to the time of processing probably influences the quality of machine-harvested grapes more than any other factor (6,7,8,9,17,18). Grapes placed in pallet boxes after harvest do not increase in temperature for 72 hr (7). The initial temperature of the grapes at harvest governs the storage temperature, regardless of the external air temperature. High temperature at harvest in combination with a delay in processing leads to

rapid deterioration of grape juice quality (7,9). Grapes harvested when fruit temperature is high (about 35°C) produce high levels of alcohol and acetic acid, both of which are signs of microbial spoilage, and have poor color (9). The alcohol and acetic acid contents of mechanically harvested grapes begin to accumulate 12 hr from the time of harvest if grape temperature at harvest is as high as 29°C and increase rapidly after 18 hr of holding at 29° or 24 hr at 24°. Decreases in soluble solids, flavor, and color quality parallel the increases in alcohol and acetic acid (7). Off-flavors in the processed juice product can be expected when alcohol levels reach 0.25%.

High temperatures (above 25°C) of grapes at harvest usually are not a problem in cool areas (1,5,15), but grapes in hot areas, such as the San Joaquin Valley of California and in the southern United States, should be harvested during cool periods of the day or at night to minimize quality loss (7).

Addition of SO₂ to machine-harvested grapes decreases quality loss during holding (1,7,8,9,17). Addition of 80 to 160 ppm sulfur dioxide immediately after harvest slowed postharvest deterioration of machine harvested grapes by delaying alcohol accumulation and loss of soluble solids for 24 hr when held at 35°C (7). Also, SO₂ discourages bacterial spoilage that might be expected at high fruit temperatures over a long period; it also serves as an antioxidant to prevent juice browning. Higher rates of SO₂ applied to machine-harvested grapes at a low temperature (24°) delayed alcohol production for 42 hr (7).

The type of containers used for hauling the grapes to the processing unit can influence product quality. Initially, 0.91 - MT (1-ton) capacity wooden bins with food-grade plastic liners were used to accommodate the fruit; however, many operations on the West coast have shifted to a 3.6- to 4.5-MT (4- to 5-ton) capacity hydraulic, self-dumping 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 have not reduced the quality of the processed product (5,6,17).

Guidelines for operators of commercial harvesters

The following guidelines were developed by our grape research group at the University of Arkansas in cooperation with the commercial grape processing industry to maintain or improve the quality of machine-harvested grapes: 1) select the proper rpm of 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); and 2) establish a time limitation from harvesting to processing plant delivery.

Other factors to be considered are fruit temperature and quality standards required for the final product: 1) prepare vineyard to eliminate MOG problems. This may require mechanically trimming low-hanging canes that interfere with harvest, removing bird nests, removing tall weeds, preparing a smooth surface to the vineyard floor, and stopping all cultivation in sufficient time prior to harvest to minimize dusty conditions during harvesting; 2) inspect the vineyard for foliar-feeding insects and, if necessary, apply required special sprays sufficiently ahead of harvest; 3) provide a bin or conveyor inspector as part of the harvesting crew. This individual would remove MOG; watch for plugging of cleaning fans, hydraulic leaks, and mechanical failures; 4) keep harvested grapes covered at all times and require a complete washing of delivery bins or containers after the grapes are dumped at the processing plant or winery; and 5) wash and clean mechanical harvesters thoroughly with an approved detergent-sanitizes at the end of each 8- to 10-hr operating shift (under some conditions a complete high-pressure water rinse may be required during the operating shift).

Summary

The most profits in vineyard mechanization has occurred using totally integrated systems that include cultural programs, harvesting principles, postharvest handling, and product utilization. Efforts must continue to refine and improve the weak areas of each of these systems if our Concord grape industry is to remain competitive.

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