EFFECTS OF MECHANICAL PRUNING AND MECHANICAL SHOOT POSITIONING ON YIELD AND QUALITY OF GRAPES.

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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.

To use machines successfully for shoot positioning, pruning, harvesting, and other grape production operations, trellis systems must be devised and shoots positioned to accommodate precise mechanical movement (6, 21). A properly trained vine should allow efficient mechanical pruning to occur without excessive damage to the vines or reductions in fruit yield and/or quality.

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One training system that accomplished these objectives was the Geneva Double Curtain training system (GDC), developed by Shaulis et al. (37) in New York. The GDC trellising system doubles the length of cordon per vine, over the Bilateral Cordon system (BC), 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. Most vigorous vines of large-leafed Vitis labrusca L. cultivars with a drooping-shoot growth habit and annual cane prunings of 1.35 kg or more at 240 cm in-the-row spacing may be expected to give the greatest response to the GDC system (17).

The GDC trellising system requires a 3-wire trellis with 2 horizontal cordon-support wires, and a single trunk support wire. 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 Vitis vinifera L., 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 Vitis labrusca vines also can be effectively pruned by machine (2,22,23,24). Research in Arkansas (2,23) that compared the 3 major trellising systems used for Concord grapes 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 GDC system can be totally mechanized; hence, these systems are recommended for Vitis labrusca cultivars in Arkansas.

Bilateral cordon (BC) training with spur pruning is currently a common training system in California vineyards (3). However, the fruiting spurs are selected from the upper 180° of the cordon since Vitis vinifera cultivars grow upright. A common BC trellis used for California wine grapes consists of a 2-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 (HTS) cordon wire is located about 105 cm above the vineyard floor. Two or three foliage support wires (13-gauge HTS) are moved upward to support the new growth (30). This system can be successfully mechanically pruned.

SHOOT POSITIONING

Effective mechanical pruning can be accomplished with Vitis labrusca species produced on the GDC or BC system 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 and of exposing the lower nodes on the bearing units to sunlight to make the basal nodes more productive than under shaded conditions (26, 37, 39). Shoot positioning has proven particularly effective in Arkansas with large vigorous vines of Vitis labrusca cultivars, which have large leaves and a drooping-shoot growth habit. Shoot positioning can be accomplished by mechanical means. A new shoot positioner, developed by Tommy Oldridge, an Arkansas grape producer, is an improvement over other machines for positioning GDC-trained vines- (Fig. 1). This machine is currently being evaluated by the author at the Arkansas Agricultural Experiment Station.
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. Shoot positioning can require a second and sometimes a third pass with a mechanical shoot positioner (six). For the GDC system, all vigorous shoots growing between the two cordon wires must be pulled or brushed down in order to maintain two separate foliage canopies.

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 pruning and tying. Grape producers complained of decreasing availability of qualified labor for pruning and tying and indicated that these should be the next operations mechanized (21). A mechanical pruning aid for Concord grapes was developed in New York by Pollock et al. (31,38) 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.

![Oldridge mechanical pruner](image)

Research on pruning mechanization 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% (21,25). 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 and more detailed study was established at the University of Arkansas to examine the effects of mechanical pruning on yield, vine size, and juice quality (Tables 1 and 2) of shoot positioned Concord grapevines on GDC or BC training systems (22,23). This study was established in a 20 year old vineyard. The vines were either mechanically pruned or were balance pruned to a 30+10 severity. The mechanically pruned vines were left untouched or were adjusted to the best 60 or 90 nodes per vine. After six 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 in this older vineyard and under conditions of this study. Both the no-touch-up treatment and retaining 90 nodes per vine following mechanical pruning treatments reduced per vine and per node fruit yields (data not shown) after the sixth year and resulted in unacceptable objective and sensory juice quality. Also, these 2 treatments resulted in uneven ripening of Concord grapes (% green fruit), which contributed to the problem of low soluble solids and poor juice color. Sensory color acceptability ratings (Table 2), which included both the parameters of color intensity and hue, generally declined with increasing treatment severity on SC-trained vines. However, the color acceptability was rated lower than expected on hand-pruned (30+10) GDC-trained vines because of the blue appearance, rather than the expected intense purple juice color. This result was due to the influence of high pH on juice color. The high pH allowed structural transformations of the anthocyanin molecule, resulting in the shift in hue. SC-trained, no touch-up vines had the lowest ratings for both color intensity and color acceptability.

Juice flavor was rated unacceptable from plots limited to 90 nodes or with no touch-up on the GDC-training system and with no touch-up treatment on the SC system, following mechanical pruning.

From this study it was concluded that continuous mechanical pruning in older Concord vineyards is recommended only in shoot positioned vineyards where pruning can be followed by cane selection and adequate node limitations. These preliminary findings indicated a need for a more definitive look at mechanical shoot positioning and mechanical pruning. A study was designed at the Arkansas Agricultural Experiment Station with the objective of examining various levels of mechanical pruning in combination with shoot positioning on Concord grapes. The vineyard was planted in 1981. The vines were extremely uniform in vigor, and all vines were trained to the GDC training system with 3rn x 2m spacing and drip irrigation. The experimental field plot was an incomplete Latin square 7 x 4 factorial (7 columns, 4 rows) with four replications. Treatments consisted of: 1) four levels of shoot positioning: a) hand positioning, b) machine positioning, c) separating the canopy by breaking centers only, and d) no shoot positioning (in treatments a, b, and c the shoots were positioned vertically toward the vineyard floor two or three times, as required) and seven pruning treatments: a) balanced pruned by hand to a 30+10 level (6 node canes), b) balanced pruned by hand to a 50+10 level (6 node canes), c) mechanically pruned and adjusted to the best 60 nodes, d) mechanically pruned and adjusted to the best 80 nodes, e) mechanically pruned with fruit removed by mechanical beating at a green-pea size to a level approximating the fruit load of a 30+10 pruning severity, f) mechanically pruned with no touch-up in even numbered years and hand pruned to 30+10 (6 node canes) in odd numbered years, and g) mechanically pruned with no-touch-up.

**Table 2.-Effect of training system and pruning treatments on sensory quality of Concord juice on the sixth and final year of the study.**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Intensity</th>
<th>Color Acceptability</th>
<th>Flavor</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30+10</td>
<td>7.8a</td>
<td>6.0ab</td>
<td>5.6cd</td>
</tr>
<tr>
<td>Mech./adj. best 60 nodes</td>
<td>7.1abc</td>
<td>7.0a</td>
<td>6.6bc</td>
</tr>
<tr>
<td>Mech./adj. best 90 nodes</td>
<td>6.9abc</td>
<td>6.3ab</td>
<td>4.8de</td>
</tr>
<tr>
<td>Mech./no touch-up</td>
<td>4.4c</td>
<td>4.9b</td>
<td>4.0e</td>
</tr>
<tr>
<td>30+10</td>
<td>7.7a</td>
<td>7.9a</td>
<td>7.6ab</td>
</tr>
<tr>
<td>Mech./adj. best 60 nodes</td>
<td>7.3ab</td>
<td>6.9ab</td>
<td>8.3a</td>
</tr>
<tr>
<td>Mech./adj. best 90 nodes</td>
<td>5.7bc</td>
<td>5.9ab</td>
<td>5.8cd</td>
</tr>
<tr>
<td>Mech./no touch-up</td>
<td>2.7d</td>
<td>2.8c</td>
<td>4.0e</td>
</tr>
</tbody>
</table>


*Means within columns followed by the same letter or letters are not significantly different at the 5% level, by Duncan's multiple-range test.

Yield, pruning weight, and juice quality have been determined for eight consecutive years. This has proven to be an extremely productive young vineyard. Unlike some of the recent research findings in other regions, our results indicate that continued mechanical pruning with no node adjustments may have undesirable effects on the fruit quality when the
mechanical pruning results in extremely high yields (Tables 3 and 4). Our main concern about mechanical pruning is its affect on percent soluble solids and color (Tables 3 and 4). Sensory quality of juice from the 1991 and 1992 seasons is currently being determined on pilot scale juice lots, using a trained panel. Shoot positioning showed reduction insoluble

![Table 3](image-url)
solids in 1991, but there was no need to position the vines in 1991 due to reduced vigor and vine size (Table 4). It was obvious that shoot positioning for sunlight exposure was not needed. The excessive heat and fruit exposure to the sun was detrimental to percent soluble solids.

<table>
<thead>
<tr>
<th>Main Effects</th>
<th>Yield (Mt/ha)</th>
<th>Pruning Weight (Kg/vine)</th>
<th>Soluble Solids (%)</th>
<th>pH</th>
<th>Acidity (% tartaric)</th>
<th>Color (520 nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoot positioning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand</td>
<td>38.6ab</td>
<td>0.39b</td>
<td>14.06e</td>
<td>3.34b</td>
<td>0.85a</td>
<td>0.106b</td>
</tr>
<tr>
<td>Machine</td>
<td>39.8a</td>
<td>0.41b</td>
<td>13.6c</td>
<td>3.36ab</td>
<td>0.85a</td>
<td>0.101b</td>
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<tr>
<td>Centers broken only</td>
<td>36.3bc</td>
<td>0.59a</td>
<td>14.5ab</td>
<td>3.43a</td>
<td>0.84a</td>
<td>0.135a</td>
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<tr>
<td>None</td>
<td>34.9c</td>
<td>0.65a</td>
<td>14.6a</td>
<td>3.39ab</td>
<td>0.84a</td>
<td>0.139a</td>
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<td>Pruning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30+10</td>
<td>36.2ab</td>
<td>0.65a</td>
<td>14.4a</td>
<td>3.34b</td>
<td>0.85a</td>
<td>0.112ab</td>
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<tr>
<td>50+10</td>
<td>37.7ab</td>
<td>0.52ab</td>
<td>14.2a</td>
<td>3.34b</td>
<td>0.84a</td>
<td>0.117ab</td>
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<td>Mech./adj. best 60 nodes</td>
<td>34.3b</td>
<td>0.61a</td>
<td>14.2a</td>
<td>3.40ab</td>
<td>0.84a</td>
<td>0.128a</td>
</tr>
<tr>
<td>Mech./adj. best 80 nodes</td>
<td>35.9ab</td>
<td>0.62a</td>
<td>14.6a</td>
<td>3.46a</td>
<td>0.82a</td>
<td>0.146a</td>
</tr>
<tr>
<td>Mech./+ fruit removal</td>
<td>37.6ab</td>
<td>0.35c</td>
<td>14.4a</td>
<td>3.39ab</td>
<td>0.86a</td>
<td>0.127a</td>
</tr>
<tr>
<td>Mech./30+10 alt. years</td>
<td>39.9a</td>
<td>0.42bc</td>
<td>14.0ab</td>
<td>3.34b</td>
<td>0.85a</td>
<td>0.121ab</td>
</tr>
<tr>
<td>Mech./no-touch-up</td>
<td>40.0a</td>
<td>0.40bc</td>
<td>13.6b</td>
<td>3.37b</td>
<td>0.83a</td>
<td>0.090</td>
</tr>
</tbody>
</table>

W 29 days over 37.4°C and 8 days over 40.6°C; 256 cm of rainfall in July and August.
X, Y, Z Means of main effects separated by Duncan's multiple range test at the 5% level. Means within main effect and column with the same letter(s) are not significantly different.

Mechanically pruned with fruit removed by mechanical beating at a green pea size to a level approximating the fruit load of a 30+10 pruning severity.
Mechanically pruned with no touch-up in even numbered years and hand pruned to 30+10 (6 node canes) in odd numbered years.
Freeman and Cullis (12) studied mechanical hedge pruning of Cabernet Sauvignon and Doradillo vines in Australia that were trained to a BC system. The following hedge shapes were established in this 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 where the vines were trimmed close to the cordon on one side on 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 the manually pruned vines, except in 1976 when the hedged Doradillo vines had lower yields. With the Cabernet Sauvignon, a triangular hedge initially had lower yields but in later years 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.

Freeman and Cullis (12) concluded vine hedging was a viable alternative to detailed manual pruning for these vinifera grapes in Australia. In another study, Freeman (personal communication, Viticultural Res. Sta., Griffith, New South Wales) reported that the major quality characteristics affected by total mechanical pruning are smaller berries and clusters. Also, he indicated that the mechanically pruned hedge presents no problems during the mechanical harvesting operation. Mechanical hedging of Vitis vinifera vines on a commercial scale is being adopted rapidly in Australia (I 1,14), where pruning cost reductions of up to 75% have been recorded (14). Machine-assisted pruning has become a fixture in the Australian wine industry (6) where winemakers have not been able to detect any change in quality of fruit coming from machine-pruned vines.

Working on the theory that winter pruning disturbs the vines’ natural process of self regulation of growth and production, Clingeleffer and Possingham (5) have developed a trellising system in Australia that requires minimal pruning and provides ideal vine conformation for mechanical harvesting. They call it Minimal Pruning of Cordon-Trained Vines. Cordon-trained vines are trained to either a single or double high wire in the vertical plane. Pruning consists of skirting at the sides only, either in winter or summer. Over the seasons, the cordons and canes grow into a large permanent canopy. Skirting can be accomplished with simple and inexpensive tractor mounted equipment. Commercial gains have been realized with this trellising system.

Pool et al. (34) have used mechanical pruning to minimal prune vineyards in New York. Pool (33) has also studied mechanical thinning and found that the resultant crop reduction enhanced juice soluble solids contents despite a poor harvest in the year of the experiment. Intrieri and Marangoni (15) reported alternate “up-down” mechanical pruning of GDC-trained Vitis vinifera grapes in Bologna, Italy, has given satisfactory results in terms of production and vegetative response of the vines for a 3-year period. After 4 years of tests and surveys, Cargnello and Lisa (1) in Veneto, Italy, concluded that for mechanical pruning to be practical it is necessary to control the bud load annually, and that 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.

Parallel work on pruning and shoot positioning mechanization has occurred in other grape growing regions of the world, e.g., Australia (3,4,18,19), New Zealand (41), France (35,43), Italy (7,8,9,32,40,42), Spain (13), Bulgaria (20,28,29,39), and the Ukrainian SSR (27). In some regions success is not or will not be possible until trellis systems are modified (36).

In summary, mechanical pruning has been more successful than expected by some research viticulturists, when using selected cultivars of both the Vitis labrusca and Vitis vinifera species. Also, fruit, juice, and wine quality has been better than expected with certain cultivars. However, regions and seasons of marginal adaptability of Concord grapes under excessive fruit loads that were created by mechanical pruning with no-touch-up or node adjustment by hand can result in poor quality fruit and juice. This author has also observed machine-pruned Vitis vinifera cultivars in Arkansas that resulted in overcropped vines, that were subjected then to a severe winter. The end results were vine damage and vine death.

Mechanical or hand removal of fruit may have prevented this winter injury problem. If these vines had been able to adjust to minimal pruning (smaller and more numerous clusters, smaller berries, and more numerous growing points) for a few seasons prior to the severe winter, this severe winter damage may not have occurred.

Under Arkansas conditions, Concord juice quality can be influenced as much or more by the growing season as by the pruning treatment. Also, the age and condition of the vines can be a factor. Under Arkansas conditions there is a need to mechanical shoot position in order to do an effective job of mechanical pruning. Both of these operations are integral parts of our total systems approach to vineyard mechanization. If research funding can be obtained, we plan to continue to evaluate the effectiveness of the Oldridge mechanical shoot positioner and pruner (Figs. 1 and 2) as part of the total mechanized system for the production of Vitis labrusca grapes in our region.

LITERATURE CITED