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Considerations for the Mechanical Pruning of Concord Grapevines

a report from the

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Center

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CONSIDERATIONS FOR THE MECHANICAL PRUNING OF CONCORD GRAPEVINES

Tom Zabadal, Gary VanEe, Richard Ledebuhr, Mike Partridge

BACKGROUND:

Pruning requires more labor than any other task in the annual cycle of vineyard management. The economics of grape production have often dictated wages for pruning of grapevines, which have led to a decreasing supply of pruning labor in many viticultural areas. Therefore, numerous efforts have been made to use mechanical devices to reduce or even eliminate the need for hand labor for this vineyard task.

In many instances individual efforts by growers to undertake mechanical pruning have resulted in long-term decline of vine size and productivity. Understandably, the observation of or direct experience with these failed efforts at mechanical pruning has led many growers to consider mechanical pruning as inferior to manual pruning and a practice that should be elected only out of desperation. However, in some vineyard applications, technological innovations for this vineyard task in recent years now position mechanical pruning and other associated vineyard practices as a viable, cost-effective alternatives to manual pruning. The discussion below reviews this topic and outlines one approach to mechanical pruning of Concord grapevines under Michigan growing conditions.

MECHANICAL PRUNING STRATEGIES

Numerous strategies have been conceived and evaluated for the mechanical pruning of grapevines. These strategies might be envisioned along a continuum of pruning severity (Fig.1). At one end of this continuum, mechanical pruning may attempt to simulate hand pruning practices with the removal of 80-90% of the mature nodes (buds) on a vine during the annual dormant season pruning of the grapevine (Fig. 2). At the other extreme the concept of minimal pruning seeks to remove during the pruning process only those nodes that are too low on a vineyard trellis to be manageable. Up to 90% of the nodes (buds) that grow on vines during the previous growing season may be retained with minimal pruning (Fig. 3). Removal of large or small percentages of nodes on a vine during pruning is termed "severe" or "light" pruning, respectively. Mechanical pruning strategies that employ light pruning lead toward the production of large crops, which under Michigan growing conditions, carries the risk in some growing seasons of producing fruit of unacceptable quality. Therefore, mechanical pruning strategies that employ light pruning need to consider crop adjustment during the growing season so that the resulting crop will be of acceptable maturity.

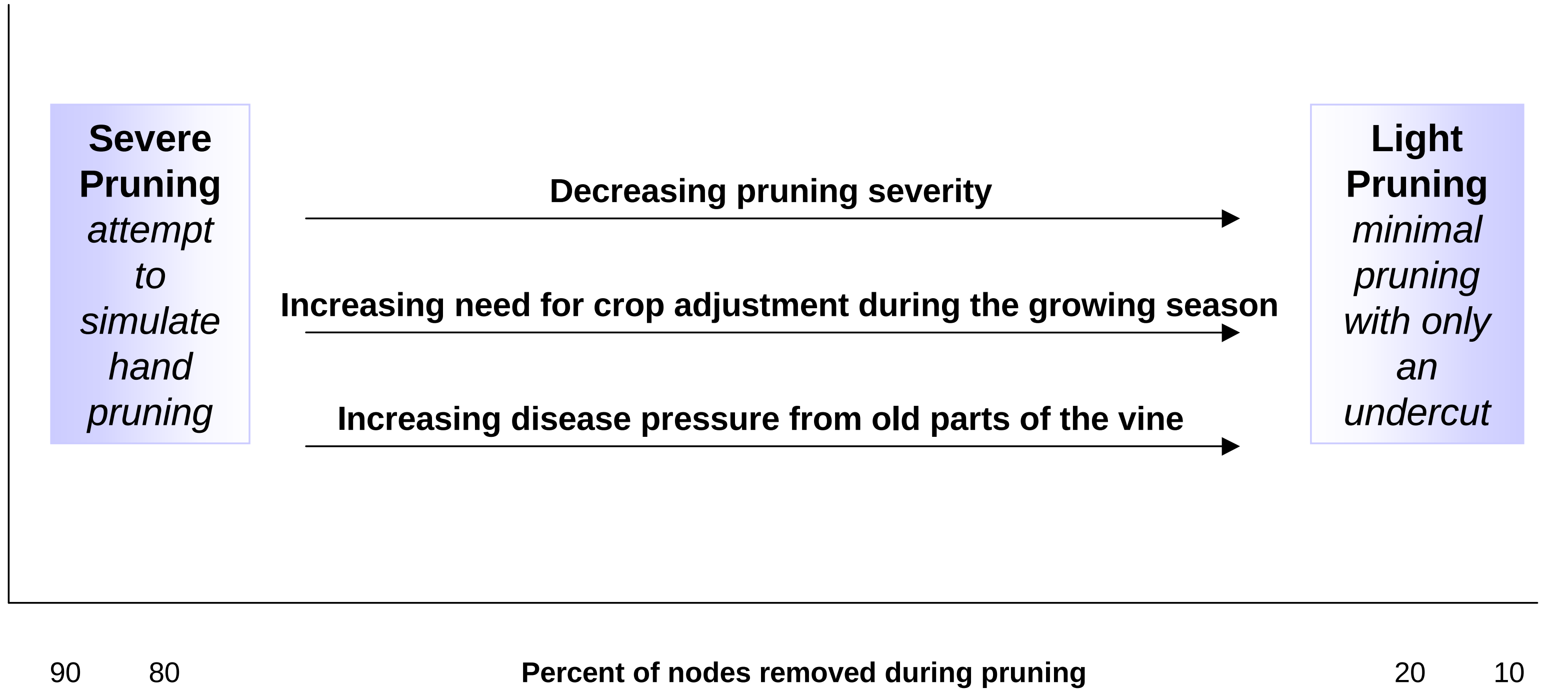

Figure 1. Mechanical pruning can be practiced with a wide range of pruning severities, which influence the need for crop adjustment during the growing season and the potential for disease pressure.

pruning_sev

Fig. 2. A Concord grapevine that has been mechanically pruned with pneumatic shears so that it looks virtually identical to manually pruned vines. Baran Farm, Chatauqua County, New York.

Fig. 3. A Concord grapevine after four years of minimal pruning. Grabemeyer Farm, Sister Lakes, Michigan.

We have evaluated several strategies for mechanical pruning of Concord grapevines in a 6-year experiment at the Grabemeyer farm. We found that use of minimal pruning, with or without crop adjustment, was no better than and in some years, worse than commercial hand pruning. Fruit soluble solids were significantly reduced with minimal pruning (Table 1). Moreover, vines in these treatments became increasingly difficult to manage. On the other hand, severe mechanical pruning provided results comparable to commercial hand pruning both in regard to yield and fruit maturity (Table 1). Manual balance pruning resulted in the lowest yields (Table 1).

Table 1. Yield, components of yield, and fruit maturity for'Concord' grapevines subjected to seven treatments involving pruning and crop adjustment. 6-year averages from 1993-1998. Grabemeyer Farm.

Description	Yield (tons/acre)	Live nodes/ foot of trellis	Yield/ node (lb)	Clusters/ foot of trellis	Cluster weight (lb)	Fruit quality		
						°Brix	pH	Titratable acidity (g/L)
Balance prune 20 + 20	4.8 bc	8.7 e	.28 a	11.7 d	.19 a	16.5 a	3.4 a	.7 a
Commercial prune	5.7 a	10.7 d	.26 a	15.8 c	.17 a	16.0 b	3.4 a	.7 a
Severe hedge	5.5 ab	18.6 c	.14 b	20.4 b	.13 b	15.9 bc	3.4 a	.7 a
6" hedge	5.8 a	22.1 b	.12 bc	21.0 b	.14 b	15.8 bc	3.4 a	.7 a
6" hedge + crop adjust	4.3 c	23.5 b	.08 d	19.3 b	.10 c	16.2 ab	3.5 a	.7 a
Minimal prune (undercut)	6.0 a	26.2 a	.10 cd	23.7 a	.12 bc	15.5 c	3.4 a	.7 a
Minimal prune + crop adjust	4.6 c	27.2 a	.08 d	20.6 b	.10 c	16.0 ab	3.4 a	.7 a
$LSD_{(0.05)}$[1]	0.9	1.7	.03	2.6	.02	.5	.1	.1

[1] Mean separation within columns using Fisher's Test for least significant difference.
[2] Insufficient data for statistical analysis.

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Crop adjustment strategies for juice grapes growing in Michigan may be mechanical, as developed by the viticultural research program in New York (Fig. 4) or chemical, as they have been investigated in several viticultural areas including Michigan (Fig. 5). At present, however, none of these crop adjustment strategies have been widely employed by commercial growers in Michigan. Some winegrape varieties are so highly fruitful (Fig. 6) that manual crop adjustment, employing either flower cluster or cluster thinning is a commercial practice. This is not economically feasible for juice grape production.

The mechanical pruning research program described below has sought to employ relatively severe pruning, i.e., that which closely simulates hand pruning (Fig. 7). The components of this program will be described. The integration of these individual components into a total mechanical pruning process will then be presented.

Fig. 4. Top view from a grape harvester being used to adjust crop size on Concord grapevines in mid-July. Green berries are somewhat visible on the conveyor belt and ground. Mihelich Farm, Teapot Dome, Michigan.

(a)

(b)

Fig. 5. Seyval blanc clusters (a) in their natural condition or (b) after chemical crop adjustment with an experimental compound. Oxley Farm, Lawton, Michigan.

Fig. 6. Numerous clusters in full bloom on a Chancellor grapevine illustrating the very high level of fruitfulness that occurs on some vines. Oxley Farm, Lawton, Michigan.

Fig. 7. A Concord grapevine after it has been cane positioned and mechanically pruned but before any hand follow-up.

MECHANICAL PRUNING

The first mechanical pruning unit in the current MSU mechanical pruning program was fabricated in 1992.(Fig. 8). The goal was to keep the unit relatively simple, low cost and yet effective. A unique gearbox, modeled after a design that was developed and manufactured by the Gillison Equipment Company for larger pieces of equipment, was used with a vertically oriented cutter bar so that there are moveable teeth on both blades. Alternating teeth were removed on these blades to create relatively wide openings between teeth. The dual blade action allows for fairly rapid closure of those teeth. A rotating wheel powered by an hydraulic motor was attached to the bottom of this cutter blade (Fig. 9). Spoked extensions from this rotating wheel with pliable rubber tubing on their ends rotate in a counter-clockwise pattern approximately 24" above the ground surface to gather canes that extend downward from vines. These canes are rotated out into the vineyard row by this rotating set of spokes so that they are oriented to be cut by the vertically-oriented cutter bar (Fig. 9). Therefore, this mechanical-pruning (also called hedging) unit is capable of making both a vertical cut along the sides of vines as well as an undercut with just the single cutter blade. Successful trials with this unit led to its commercialization in 1995.

Fig. 8. A prototype mechanical pruning device constructed by the MSU Department of Ag Engineering. It features a dual-action cutter bar and rotating tines at the base of the cutter bar.

Fig. 9. A close-up of the rotating tines at the base of the cutter bar of an MSU prototype mechanical pruning unit. These tines move canes out from under the trellis into the path of the cutter bar.

CANE POSITIONING

The mechanical pruning unit described above as well as with numerous others often produce inadequate pruning severity when no other steps are taken in the pruning process. That is, vines that are only hedged often retain too many fruiting nodes so vines develop too large a crop with unacceptable fruit quality for the intended market. Prior experience with mechanical pruning by growers in the Finger Lakes region of New York indicated that with sufficient hand follow-up, a desired level of pruning severity could be obtained. However, that required as much as eight hours of hand pruning per acre or more. Therefore, efforts were begun to reduce the amount of hand follow-up required after hedging. Many of the excess, undesirable nodes retained on Concord vines after hedging are situated on canes running along the top of the trellis (Fig. 10). It was reasoned that if those canes could be moved out, away from the cordons at the top of the trellis, then they would be better targets for the hedging operation and pruning severity could be increased as desired. Therefore, considerable effort over a several-year period was made to develop a device that would reposition these canes. The basic design of this device is a set of rotating heads with a series of spring-loaded metal tines (Fig. 11). They rotate in an orientation similar to shoot positioning devices that were originally designed by Mr. Jim Merritt in Chatauqua County, New York and later commercialized by the Slawson-Mead Company. After numerous efforts, a cane positioning head with a proper design, tine orientation and durability was field-tested beginning in 1998 (Fig. 12). Since that time it has performed well under a variety of conditions.

Fig. 10. Concord grapevines after mechanical pruning. Numerous canes running along the top of the trellis were missed during the pruning process. Cane positioning corrects this situation.

Fig. 11. Cane positioning being performed on a Concord vineyard. This unit can be quickly converted to a mechanical pruning operation. Baiers Farm, Bainbridge Township, Michigan.

Fig. 12. Cane positioning on Concord vines using the fully-developed version of the device. Blum Farm, Lawton, Michigan.

SHOOT POSITIONING

During the process of developing a cane positioning device, it was also evaluated during the growing season as a shoot positioning device (Fig. 13) to enhance fruit exposure (Fig. 14) and overall fruit quality. Treatments included positioning at 2, 4 and 6 weeks after bloom and combinations thereof. Results of this experiment at the Baiers Farm (Table 2) indicate that mechanical shoot positioning 2 weeks after bloom significantly increased fruit soluble solids accumulation by an average of 0.4 °Brix for the several-year period of the experiment with no influence on yield. Although later times of shoot positioning and multiple times of shoot positioning were also capable of increasing fruit soluble solids in some years, these treatments were associated with significant reductions in vine yield.

Fig. 13. Mechanical shoot positioning Concord grapevines with an MSU-Ag Engineering prototype at Southwest Michigan Research and Extension Center, Benton Harbor, Michigan.

(a) (b)

Fig. 14. Concord grapevines (a) before and (b) after mechanical shoot positioning when applied two weeks after bloom. Baiers Farm, Bainbridge Township, Michigan.

Table 2. Yield and °Brix on 'Concord' grapevines trained to Hudson River Umbrella (cordon) and managed with varying times of shoot positioning. Four-year average from 1995 through 1998 plus low and high years for °Brix. Baiers Farm.

Time of shoot position (weeks after bloom)	Yield	°Brix		
	4-year avg	4-year avg	Low	High
Control	6.4 a	15.5 c	14.7	16.4
2	6.4 a	15.9 a	15.3	17.0
4	5.9 ab	15.9 ab	14.7	16.8
6	5.5 b	15.6 bc	14.6	16.7
2 + 6	5.6 b	15.9 ab	15.0	17.0
2 + 4 + 6	5.5 b	15.8 abc	14.3	16.7
$LSD_{(0.05)}$[1]	0.7	0.3		

[1] Mean separation according to Fisher's Test for least significance. P <= 0.05. doc1349_brix

PREPARING A VINEYARD FOR MECHANICAL PRUNING

The project reported here evolved over a period of eight years. It has involved numerous Concord vineyards in Southwest Michigan. Although some of the trials in this project have been performed on vines employing Umbrella Kniffin training, most of the efforts have involved vines trained Hudson River Umbrella (top-wire cordon) training. Therefore, this approach to mechanical pruning is specifically directed to Concord vines trained in that manner. It has become apparent over the many years of effort that successful mechanical pruning requires vines to be trained to a stable, well-engineered trellis. Vines with sagging cordons and crooked trunks are poor candidates for this activity. Trellises with loose wires not only promote poor vine structure but they make it difficult-to-impossible to apply the mechanization procedures described below. Therefore, a first step towards applying mechanical pruning to an existing vineyard may require upgrading of trellis and vine structure. The planting of new vineyards, for which mechanical pruning will be considered, should include proper trellis engineering.

Mechanical pruning is best suited to medium-to-large sized vines, which are capable of tolerating the less precise pruning severity achieved through mechanization than with hand-pruning. Therefore, unless the grower desires to "milk" old vineyards with small vine size for crops in the terminal years of the vineyard's existence, vineyards with small vine size should not be considered for mechanical pruning. When mechanically pruning vineyards with moderate-to-large vine size, cultural practices to continue stimulating vine size to include weed control, fertilization and pest management will be important for making mechanical pruning sustainable.

Mechanical pruning of the type described here is non-selective for the nodes retained on the vine. Therefore, the level of fruitfulness of nodes retained will be less than for vines pruned by hand (Table 2). As a result, it will be necessary to retain more nodes on mechanically-pruned vines than for those hand-pruned to obtain the same level of fruiting potential. The nodes pruned in the first year of mechanical pruning are often still highly fruitful because they developed on vines, which were pruned relatively severely by hand in the previous year. Therefore, a grower should increase node numbers per vine by about 20%. However, by the second year of mechanical pruning node fruitfulness will drop off considerably so it will often be necessary to increase node numbers per vine by 50% over hand pruning. For example, if a grower had traditionally been retaining 50 nodes per vine on large Concord vines, he should consider increasing that by 20% the first year to 60 nodes and 50% in succeeding years when utilizing mechanical pruning so that he would now retain 75 nodes per vine. With that general guideline a grower should adjust his severity of pruning up or down depending upon the vine size, yield and fruit quality experience of the vineyard.

STEPS IN A MECHANICAL PRUNING STRATEGY FOR CONCORD GRAPEVINES

Step 1 Shoot positioning - A single pass of shoot positioning should be performed approximately 2 weeks after bloom. This will not only enhance the development of fruit soluble solids in most years, but it will also initiate the process of reorienting shoots so canes will be better targets for mechanical pruning.

Step 2 Cane positioning - Although shoot positioning 2 weeks after bloom will have a positive significant impact on fruit maturity and shoot orientation, many shoots will grow after this shoot positioning and establish themselves along the top of the trellis. Cane positioning will complete the reorientation of most of the canes prior to mechanical pruning. This task is often performed at a ground speed of approximately 3-4 mph so that 1 acre of vineyard can be cane-positioned in approximately 20 minutes.

Step 3 Cordon renewal, trunk renewal and managing unpositioned canes - Mechanical pruning may eliminate canes that are needed for cordon renewal or trunk renewal. Therefore, perform these tasks prior to mechanical pruning. Portions of cordons that may have become loosened from the top wire are still useful and should be reattached prior to the hedging operation. Lastly, a small percentage of canes, which run along the top of the trellis and are not moveable by cane positioning, should be pruned by hand or reoriented prior to mechanical pruning.

Step 4 Mechanical pruning - When all of the above steps have been performed, the actual process of mechanical pruning can proceed. Typically this is performed at a ground speed of approximately 1 mph and takes about 2 hours per acre of vineyard. Growers often develop many of their own refinements to increase the ease and efficiency of this task (Fig.15). Some of these refinements include (a) the pitch of the cutter blade relative to the plane of the trellis so that it becomes more or less aggressive as it is tilted toward the trellis, (Fig. 16), (b) the use of a foot pedal to instantly stop or reverse the action of the cutter (Fig. 17) or (c) the angle of the cutter blade from vertical so that as the top portion of the cutter blade is angled out away from the trellis, canes are pruned less severely at the top and left longer than if the cutter bar was positioned vertically.

Step 5 Follow up - The above steps can achieve a high level of pruning efficiency in vineyards that are properly prepared for this procedure. However, even under the best conditions, some additional pruning will be necessary. Therefore, walk the rows to remove any portions of vines that have obviously been missed.

Fig. 15. Controls for a mechanical pruning device that promote ease of operation. Blum Farm, Lawton, Michigan.

Fig. 16. Mechanical pruning device showing the aggressive orientation of the tines on the cutter bar as they point towards the trellis. Blum Farm, Lawton, Michigan.

Fig. 17. A foot pedal override on a mechanical pruning device that can stop or reverse the action of the cutter bars. Oxley Farm, Lawton, Michigan.

ECONOMICS OF MECHANICAL PRUNING - Will the above procedure cost as much as, more or less than hand pruning? Probably all three of these options will be true, depending upon the specific vineyard situation. Therefore, a grower should evaluate his cost of hand pruning versus the cost of mechanical pruning. A very generalized outline for comparing these costs is presented on the next page.

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PRUNING BUDGETS PER ACRE OF VINEYARD

Examples:

I. MANUAL PRUNING

Assumptions: 9' x 8' planting and 22¢/vine piecework

605 vines/acre x 22¢/vine = $133.10

$133.10 x $.14 (Workers Comp. + SS) = $18.63

TOTAL = $151.73

II. MECHANICAL PRUNING (includes the benefits of shoot positioning)

Assumptions:

(a) $7500 mechanical pruning equipment
(b) 10 year amortization of this equipment
(c) 75 acres pruned/year
(d) $500/year maintenance of pruning equipment
(e) $12/hr tractor cost
(f) $12/hr tractor operator
(g) $8/hr pruning follow-up

Equipment Costs:

Pruning equipment depreciation =

7500 (a) / 10 (b) / 75 (c) = $10

Equipment maintenance = 500 (d) / 75 (c) = $ 7

Tractor cost = 12 (e) x 3[1] = $36

Equipment subtotal = $53

[1] Tractor hrs = 0.5 shoot position + 0.5 cane position + 2.0 hedging = 3.0

Labor:

Shoot position 0.5 hrs x $12 (f) = $ 6

Cane position 0.5 hrs x $12 (f) = $ 6

Hedging 2.0 hrs x $12 (f) = $ 24

Hand work (prior to hedging) 3.0 hrs x $8 (g) = $ 24

Hand work (after hedging) 2.0 hrs x $8 (g) = $ 16

Labor subtotal = $ 76

TOTAL $129

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Your Estimate:

MANUAL PRUNING

__________ vines/acre x ______¢/vine = _________

_________ x ________ (WC + SS) = _________

TOTAL = _________

MECHANICAL PRUNING

Assumptions:

(a) $_________ mechanical pruning equipment
(b) __________ years of amortization
(c) __________ acres pruned/year
(d) $_________/yr maintenance of equipment
(e) $_________/hr tractor cost
(f) $_________/hr tractor operator
(g) $_________/hr pruning follow-up

Equipment Costs:

Pruning equipment depreciation =

________ (a) / _______ (b) / _______ (c) = ________

Equipment maintenance = _____ (a) / _____ (c) = _______

Tractor cost = ______ (e) x _____ hrs = _______

Equipment subtotal = $_______

Labor:

Shoot position ____ hrs x ______ (f) = _________

Cane position ____ hrs x ______ (f) = _________

Hedging ____ hrs x ______ (f) = _________

Hand work (prior to hedging) ____ hrs x ______ (g) = _________

Hand work (after hedging) ____ hrs x ______ (g) = _________

Labor subtotal = _________

TOTAL _________