A Preliminary Comparison Between

Manual and Mechanical Pruning of the Muscadine Juice Cultivar 'Carlos'

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Key findings (numerical data trends):

- **Mechanical pruning can save pruning expenses and complete dormant pruning faster when compared to manual pruning.**
- **Mechanical pruning results in the retention of greater bud numbers but less-productive buds relative to manual pruning.**
- **Retention of approximately 20 buds per foot of cordon resulted in a bud productivity between 0.15 and 0.30 lb of crop per bud; retention of approximately 30 buds per foot of cordon or more resulted in bud productivity below 0.15 lb of crop per bud.**
- **Mechanical pruning increased crop yield by an average of 1.25 tons per acre when compared to manual pruning over the 2-year study.**
- **Manual pruning increased Brix by an average of 0.7 when compared to mechanical pruning over the 2-year study.**

Introduction and background

Dormant pruning is an annual practice that removes excessive grapevine wood to regulate crop yield and maintain perennial vineyard health and sustainability. Many vineyards *preprune* by hedging to remove a large portion of the unwanted 1-year-old growth. *Final pruning* sets the bud density on the retained portions of fruitful, 1-year-old wood (Figure 1). In muscadine vineyards, the final prune is manually or mechanically implemented. Manual dormant-pruning involves hand labor to cut and remove 1-year old growth while mechanical pruning involves cutting back 1-year-old growth with a tractor-mounted mechanical pruner (Figure 2).

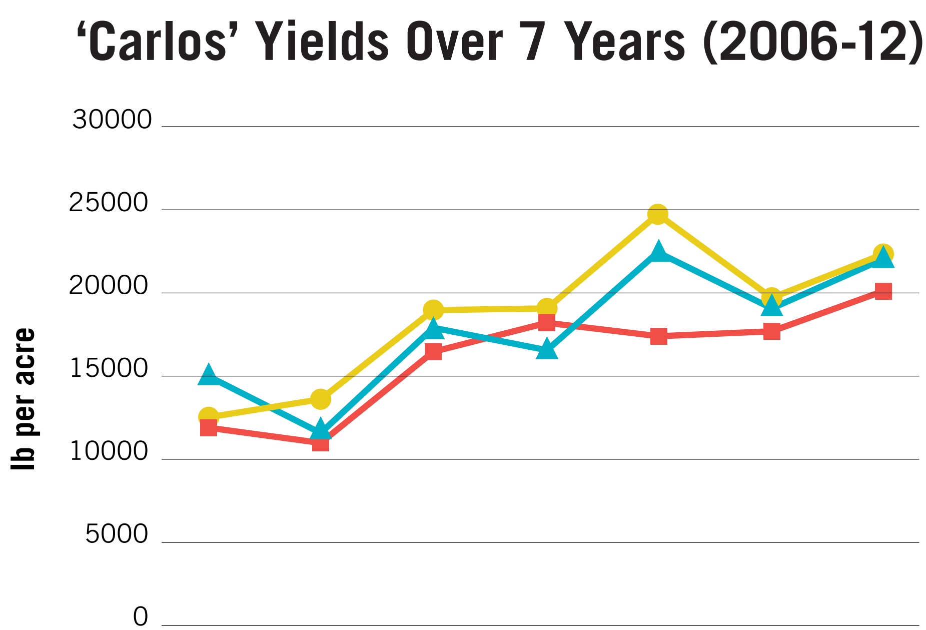
Figure 1. A dormant muscadine vineyard (top) or vine (middle) before pruning and 1-year-old muscadine "fruiting spurs" retained after manual pruning (bottom).

Note: In the photo on the bottom, the cinnamon-colored wood, which was green tissue in the previous season, is expected to produce fruitful shoots from its buds in the forthcoming season.

Figure 2. A tractor-mounted mechanical pruner in a dormant muscadine vineyard.

Two non-exclusive factors that may determine the method by which muscadine vineyards are final-pruned are the labor-to-acreage ratio and the type of muscadine cultivar being grown. In a very general sense, low labor-to-acreage ratios will necessitate mechanical pruning to optimize the ability to finish pruning before bud break in the spring. Muscadine cultivars can be classified as *fresh market* or *juice* cultivars (Conner, 2020). Fresh-market cultivars, such as 'Fry', 'Pam', 'Supreme', 'Lane', and 'Paulk', are most marketable when fruit is free from cosmetic defects. Thus, mechanical pruning may not be best practice in situations where fresh-market cultivars actually will be sold for fresh-market consumption (fresh-market cultivars are sometimes processed). Manual pruning to targeted bud densities can limit canopy congestion, which improves spray penetration and rot management, and ultimately can reduce cosmetic defects of fruit. Decongested canopies also can aid harvest efficiency in fresh-market cultivars, which are handpicked. Juice cultivars, such as 'Carlos' and 'Noble' (Figure 3), are processed to make wine, juices, jams, and other value-added products. Mechanical pruning may be a better option for implementation in juice-cultivar vineyards, as those cultivars are often marketable even when blemished. Further, market value for juice cultivars is lower than that of fresh-market cultivars. Mechanical pruning may be viewed as an opportunity to reduce input costs and improve the fiscal situation of muscadine-vineyard enterprises.

Figure 3. Mechanically harvested 'Noble' (foreground) and 'Magnolia' and 'Carlos' (background) bins ready for pressing into juice for wine production.



	2006	2007	2008	2009	2010	2011	2012
200 buds	12266	11164	16509	18265	17446	17822	20230
300 buds	15189	11835	18051	16784	22754	19359	22280
400 buds	12362	13512	19004	19100	24873	19782	22350

Figure 4. The effect of pruning to 200, 300, and 400 buds per vine (10, 15, and 20 buds per foot of cordon, respectively) on 'Carlos' yields over 7 years.
Adapted from A Step-by-Step Approach to Pruning Carlos Muscadine Grapevines, *by E. B. Poling, 2013. Copyright 2013 by N.C. State University.*

‘Carlos’ is the most widely planted muscadine cultivar in the United States (Hoffmann et al., 2020). ‘Carlos’ is a vigorous and productive muscadine cultivar, often producing more than 8 tons of grapes per acre in commercial vineyards. Early extension publications suggested that ‘Carlos’ should be pruned to approximately 7.5 buds per foot of cordon (150 buds per vine; Poling, 2003). Recent findings suggest that retaining greater bud numbers could be a more economically sustainable model for pruning ‘Carlos’ (Poling, 2013). For example, over a 7-year period, retaining 400 buds per vine produced an average yield increase of 2,469 lb per acre when compared to pruning to 200 buds per vine (Figure 4). Thus, pruning to greater bud numbers (e.g., > 15 to 20 buds per foot of cordon) may translate into greater vine productivity and return revenues over time. Mechanical pruning is anticipated to result in the retention of greater than 10 buds per foot of cordon. However, mechanical pruning is an imprecise practice and some of the retained buds may be less fruitful (as further discussed below), which would reduce revenues. While there is an up-front cost for purchasing a tractor-mounted mechanical pruner, mechanical pruning is anticipated to result in labor savings over time when compared to manual pruning. Given that ‘Carlos’ is a productive juice cultivar that can bear large crop yields over the large acreages in which it is planted, and mechanical pruning results in labor and cost savings, it was of interest to compare the effects of mechanical and hand pruning in a ‘Carlos’ vineyard.

Experimental design and methods

Mechanical and manual pruning treatments were implemented in randomized blocks in a commercial ‘Carlos’ muscadine vineyard that was planted in 2013 in Braselton, GA. The soil type was Cecil Sandy Loam. Manual pruning was implemented in all vines in the year prior to the experiment. Rows were spaced 10 ft apart and vines were spaced 18 ft apart within rows[1]. Cordon lengths were measured to account for empty trellis space and to express measurements on the basis of linear foot of cordon. Each block was comprised of two vines that were mechanically pruned and two that were hand-pruned. There was a total of five blocks in the experiment and the same experimental vines were used in both 2018 and 2019. Formal statistical analyses were not performed. The data represents means of five blocks and includes variability; “increase” and “decrease” refer to numerical (and not statistical) differences throughout the publication. Mechanical pruning was implemented with a gas-powered hedge trimmer to create a “box” that was approximately 5–8 in. long on both sides and top, but cut close (2 in.) to the bottom of the fruiting cordon (Figure 5). Manual pruning was implemented with hand shears in a fashion that was representative of commercial management; two to four buds were generally, but not always, retained on growth from the previous season (Figure 5). In general, 2018 was cloudy and rainy while 2019 was sunny and dry.

[1] In some cases, data is presented on the basis of either linear foot of cordon or acre. Data presented on the basis of a linear foot of cordon will allow calculation for the row spacing in each vineyard. Assuming a trellis void of missing production, row spacing impacts crop yield per acre more so than does in-row vine spacing. This study was conducted in a vineyard that was planted at 10-ft row spacing; data presented on a per-acre basis will increase in vineyards with closer row spacing (e.g., 9 ft) and decrease in vineyards with wider row spacing (e.g., 12 ft).

Figure 5. Examples of cordon sections from manual (left) and mechanical (right) treatments.

Results and Discussion

Time to execute: Since all vines in the experiment were not equal in total cordon length, labor time was standardized to a linear foot of cordon, and then acre, basis (Figure 6). Using the methods employed herein, mechanical pruning saved an equivalent of 40 hr of pruning labor per acre when compared to manual pruning.

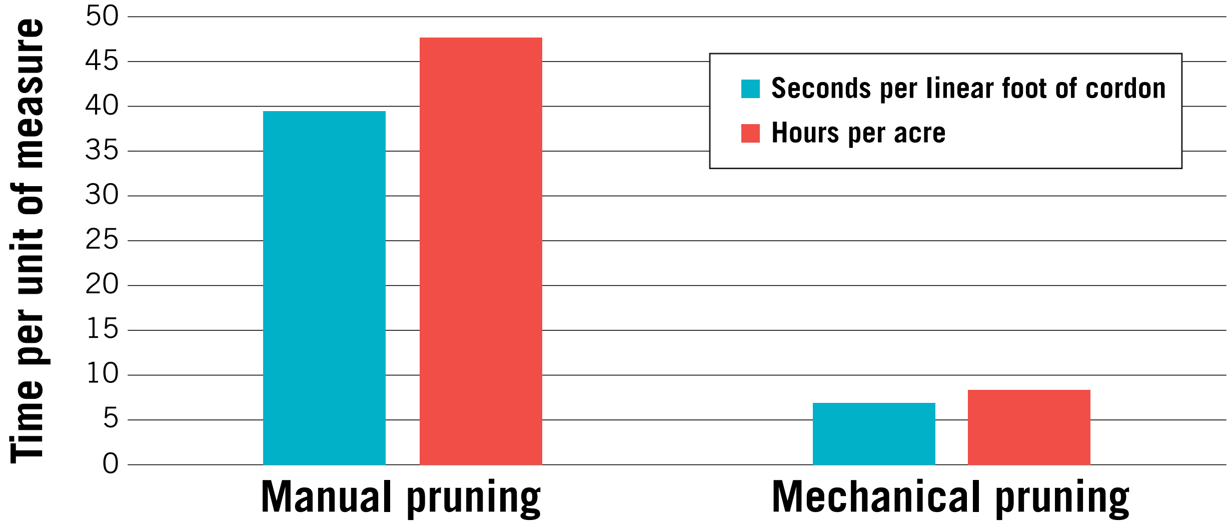


Figure 6. Pruning method effect on time required to dormant prune.

From a practical perspective, it would take an estimated 950 hr to manually prune a 20-acre 'Carlos' vineyard, while it would take an estimated 160 hr to mechanically prune that same acreage with the methods previously described. A tractor-mounted mechanical pruner works faster, but perhaps with less accuracy and precision, when compared to using the hedge trimmers in our study. A commercial grower estimated that it takes 2 to 4 hr to mechanically prune an acre of dormant muscadine vines using a tractor-mounted pruner. Using a conservative rate of 5 hr per acre, it would take an estimated 100 hr to prune a 20-acre 'Carlos' vineyard using a tractor-mounted pruner. At a labor rate of $15 per hour, mechanical pruning (with tractor operator) would save an estimated $563 in pruning labor per acre when compared to manual pruning; savings incurred by mechanical pruning would be $11,260 over a 20-acre vineyard. Tractor-mounted, mechanical pruners cost approximately $6,500 to $8,000. Thus, it is estimated that the up-front cost of the mechanical pruner could be covered over one dormant season in a commercial muscadine vineyard with at least 15 acres. More importantly, because of its efficiency, mechanical pruning could optimize the ability to finish pruning across large acreages before bud break and shoot growth resumes in the spring.

Bud density: Treatments were not implemented to target a bud density. Instead, total bud numbers on 1-year-old vine wood were counted on each vine to define treatment effect on bud density. Greater bud densities existed in mechanically pruned vines relative to manually pruned vines (Figure 7). When compared to manually pruned vines, mechanically pruned vines retained 25 and 65 more buds per linear foot of cordon in 2018 and 2019, respectively. The average bud densities in manually pruned vines were only about four buds per linear foot of row greater than a recent recommendation for 'Carlos' production (400 buds per vine with 20-ft vine spacing within the row; Poling, 2013). Thus, the extra bud densities in the mechanically pruned vines were in comparison to recent pruning recommendations in commercial 'Carlos' vineyards. The remarkable increase in bud density in mechanically pruned vines from 2018 to 2019 was speculated to be a function of the growth of shoots in 2018 that were not thinned out and increased retention of buds within the mechanically pruned box over time. Manual pruning presents the opportunity to thin spurs and unwanted dormant wood with relatively greater precision and is likely necessary when mechanical pruning is implemented over time.

Greater bud numbers existed at the trunk and decreased toward the end of the cordon (data not shown); this trend was exaggerated more so in the mechanically relative to manually pruned vines, suggesting that the human eye helps attenuate differences in production along the cordon. This observation supports the common anecdote in commercial muscadine vineyards where strong growth at the "crown" or "head" region (where the trunk meets the fruiting wire) results in the retention of large spurs containing remarkable bud numbers.

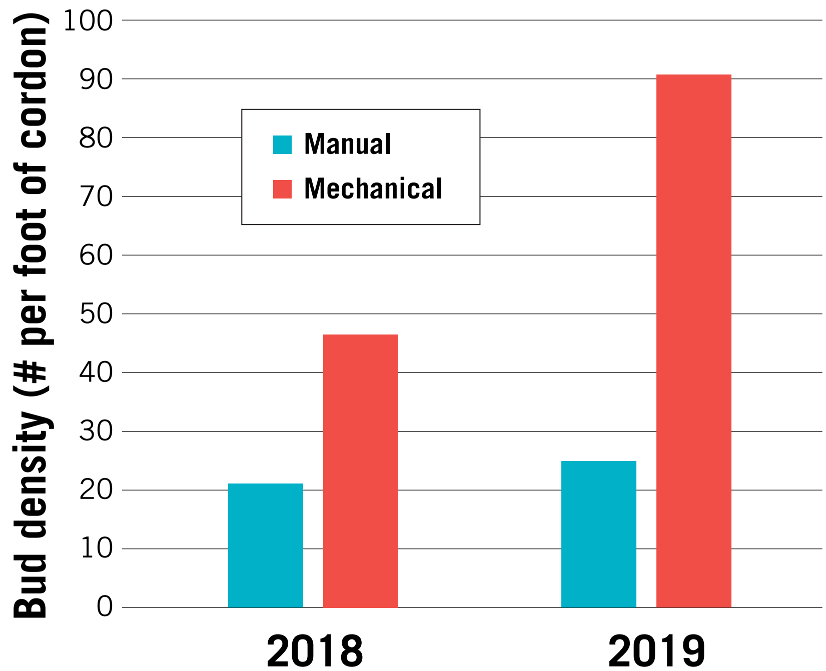


Figure 7. Pruning method effect on bud density.

Crop yield and bud productivity: Crop yield was greater in mechanically pruned vines relative to manually pruned vines (Table 1). Mechanical pruning resulted in 0.8 and 0.3 more pounds of crop per foot of cordon when compared to manual pruning in 2018 and 2019, respectively. When compared to manual pruning and assuming no missing cordon production across an acre, mechanically pruning produced an equivalent of 1.8 and 0.7 more tons of crop per acre in 2018 and 2019, respectively. Greater row spacing would lessen these estimated crop yields. While results are preliminary, these crop yield trends may indicate the mechanical pruning cannot sustain high crop yields on a perennial basis; this is perhaps due to the retention of buds that are not productive, as further discussed below. It also is possible that the drier growing season in 2019 resulted in a depressed berry weight and overall tonnage when compared to these responses in 2018.

Table 1. Pruning method effect on crop yield.

	Crop yield (tons per acre equivalent)[a]	
	2018	2019
Manual	10.6	9.4
Mechanical	12.4	10.1
	Crop yield (lb per ft of cordon)	
	2018	2019
Manual	4.9	4.3
Mechanical	5.7	4.6

[a]Calculated using the crop yield per foot of cordon, crop yield was calculated and expressed on a per-acre basis assuming no missing cordon production in the 18 x 10-ft (vine x row) spacing in the experimental vineyard.

The percent of total crop yield was consistent across cordon region and minimally affected by pruning method (Table 2). Average bud productivity tended to increase moving from trunk to cordon end. Bud productivity was more than doubled across all cordon regions in manually relative to mechanically pruned vines. Bud productivity tended to increase as bud density decreased (Figure 8). These trends suggest that the retention of 30 or more buds per foot of cordon can reduce bud productivity to less than 0.15 lb of crop per bud. In the case of mechanical pruning, many buds are retained without the aid of human precision and pruning choice. Thus, mechanical pruning is likely to retain several buds that may either never produce shoots and/or produce unfruitful shoots.

Table 2. Pruning method effect on crop yield and bud productivity based on cordon region.

	% total crop yield[b]		
	Trunk	Mid	End
Manual	33	33	34
Mechanical	35	32	33
	lb of crop per bud		
	Trunk	Mid	End
Manual	0.19	0.20	0.23
Mechanical	0.08	0.08	0.11

[b]Cordon region yield expressed as a percentage of total crop yield per vine.

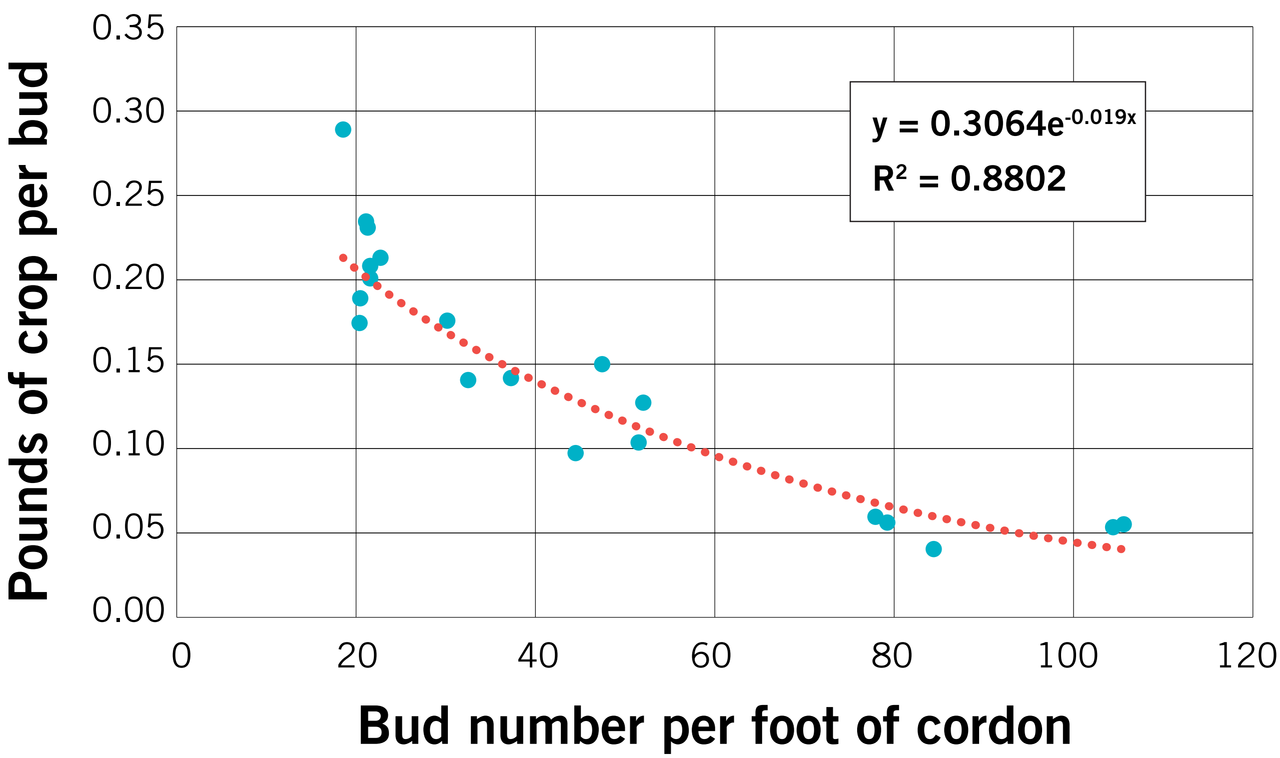


Figure 8. Bud density vs. bud productivity.

Primary fruit composition: Manual pruning consistently resulted in an average increase of 0.7 Brix when compared mechanical pruning (Table 3). This was possibly because crop yield was lower in manual compared to mechanical pruning plots. Treatments had no remarkable effects on juice pH or titratable acidity levels. Average berry weight was approximately 1 g lower in 2019 (3.9 g) relative to 2018 (4.9 g; data not shown). The lower berry weight in 2019 was likely a function of the dry and warm weather experienced in that season. Berry weight and weather patterns were likely two factors that collectively resulted in elevated Brix levels and depressed titratable acidity levels in 2019 relative to 2018. While smaller berry size can result in a greater concentration of both sugars and acids, acidity is often reduced in hot and dry weather conditions similar to those experienced throughout the 2019 season.

Table 3. Pruning method effect on primary fruit composition at commercial harvest.

	2018		
	Brix	pH	Titratable acidity (g/L)
Manual	12.8	3.1	4.8
Mechanical	12.0	3.1	5.0
	2019		
	Brix	pH	Titratable acidity (g/L)
Manual	18.8	3.2	3.4
Mechanical	18.2	3.2	3.4

Conclusion

Results from the study are preliminary as only 2 years of data have been collected and formal statistical analyses were not performed. Research over longer periods of time will be more revealing about how mechanical pruning will impact the perennial crop yield and health of the vineyard. Mechanical pruning is an option for dormant-pruning 'Carlos' in situations where labor is unreliable and/or there is a low labor-to-acreage ratio that precludes the ability to finish pruning in the dormant period. Concerns remain regarding the inaccuracy of mechanical pruning and the resultant amount of diseased and unproductive grapevine wood that may remain in the canopy. Bud productivity appears to decline as bud density increases; it is possible that greater amounts of unfruitful wood will be retained if mechanical pruning is implemented over long periods of time without periodic hand-pruning intervention. Therefore, in order to reduce canopy congestion and the potential for disease buildup in vineyards that are primarily mechanically pruned, manually pruning blocks (either completely and/or to thin fruiting spurs) on a recurring basis may be a good practice. Mechanical pruning 'Carlos' and 'Noble' vineyards is worth consideration as these popular juice muscadine cultivars are vigorous and productive and may therefore sustain perennial health under high bud densities. Mechanical pruning (as a final pruning practice) is not recommended in fresh-market muscadine cultivars, particularly if the fruit will be marketed for fresh consumption, and especially in cultivars that produce bronze fruit with greater rot susceptibility than cultivars that produce purple fruit. Mechanical pruning may further be unsuitable in young (5 years old or less), unhealthy, or otherwise low-vigor vineyards wherein the retention of high bud densities could compromise perennial health and crop productivity. The goal of this publication was to review the practical considerations when comparing manual and mechanical pruning implementation in muscadine production. The presented data are limited by the methods used in one muscadine cultivar, the 2-year time frame of data collection, and the lack of formal statistical analysis. Because of the preliminary nature of this report, it is recommended that mechanical, or "minimal" pruning, be trialed in sections of commercially mature vineyards before it is implemented with confidence throughout entire blocks or the entire vineyard.

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