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FEASIBILITY OF DIFFERENT HARVEST METHODS FOR CIDER APPLES: CASE STUDY FOR WESTERN WASHINGTON

By
Suzette P. Gallinato, Research Associate, IMPACT Center, School of Economic Sciences, Washington State University, Pullman, WA. **Carol A. Miles**, Professor and Vegetable Extension Specialist, Department of Horticulture, WSU Mount Vernon Northwestern Research and Extension Center, Mount Vernon, WA. **Travis R. Alexander**, Graduate Research Assistant, Department of Horticulture, WSU Mount Vernon Northwestern Research and Extension Center, Mount Vernon, WA

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Preface

The results presented in this publication serve as a general guide for evaluating the economic feasibility of two different harvest methods—hand and mechanical—for cider apples grown in western Washington as of 2015. Specific budget assumptions were adopted for this study, but these assumptions may not fit every situation since production costs and returns vary across orchard operations depending on the following factors:

- Capital, labor, and natural resources
- Crop yield
- Cultural practices
- Input prices
- Orchard size
- Cider apple prices
- Management skills
- Type and size of machinery and irrigation system

To avoid unwarranted conclusions for any particular orchard, readers must closely examine the assumptions made in this publication, and then adjust the costs, returns, or both as appropriate for their operation.

Harvesting Cider Apples

In the U.S., cider fruit is typically harvested by hand, just as dessert apples are harvested. A study in western Washington estimated that hand harvest accounted for 46% of the total annual variable costs when an orchard is in full production (Galinato et al. 2014).

Many cider apple cultivars are small-fruited; therefore, it can take up to four times longer to handpick one bin of cider apples than one bin of dessert apple cultivars (Miles and King 2014). Harvest labor is a primary cost consideration for cider apple growers, and it could potentially be reduced by refining mechanical harvesting of apples.

From 2014–2015 at the experimental orchard in WSU Northwestern Washington Research & Extension Center, Mount Vernon (NWREC), two rows of replicated specialty cider cultivar Brown Snout were hand harvested and mechanically harvested in a proof-of-concept experiment to evaluate the cost effectiveness of introducing mechanization to the harvest of cider apples. An over-the-row small fruit harvester (Littau OR0012) was used. While the size, shape, and yield of the trees in this experiment do not represent a commercial production system, data gathered provide a preliminary comparison of the two harvest methods in terms of weight of total harvested fruit and total labor hours for harvest. One yield was recorded for the hand harvest treatment, a method currently practiced by cider apple growers that included the fruit picked from the trees and the fruit that fell to the ground. For mechanical harvest, yield was a total of (1) fruit that was collected by the machine harvester, (2) fruit that fell out of the machine during harvest, and (3) fruit left on the trees during mechanical harvest. Efficiency of mechanical harvest was compared to hand harvest for total mechanical harvest yield. Table 1 shows the estimated yield and comparison of labor efficiency for the different variables considered for the mechanical harvester (i.e., with and without post-harvest cleanup). Based on a 2-year average (2014–2015), study results showed that:

- The yield for hand harvest and total yield for mechanical harvest were 11,760 lb/ac and 11,392 lb/ac respectively. Thus, the picking efficiency of total yield of mechanical harvest relative to hand harvest was calculated as 97%.
- For mechanical harvest, total yield included fruit picked by the machine and fruit cleaned out from the harvester (8,699 lb/ac), fruit that fell to the ground during harvest (831 lb/ac), and fruit that remained on the tree and was handpicked (1,862 lb/ac).
- Total labor hours for mechanical harvest (including post-harvest cleanup) was about 23% lower than that of hand harvest.

This publication enables growers to estimate the costs and benefits of mechanical harvest in comparison with hand harvest. Given that many factors affect cider apple production costs and returns, individual producers are encouraged to use the Excel Workbook provided to estimate their own costs and returns.

Sources of Information

In the enterprise budget for cider apples in western Washington, Galinato et al. (2014) estimated production costs and returns, including the labor cost of hand harvest. This enterprise budget served as the benchmark for comparing the costs associated with mechanical harvest in this publication. The return for cider apples was obtained from a survey of cider producers and cider apple growers in Washington State (Galinato et al. 2016). The price depends on the cider apple cultivar and, in general, the price range of cider apples in western Washington as of 2015 was between $0.25–$0.50/lb.

Data for hand harvest and mechanical harvest were obtained from the experimental cider apple orchard at the WSU Mount Vernon NWREC. Miles et al. (2016) measured different variables, particularly the number of trees harvested, number of workers during harvest, pre-harvest ground fall yield (kg), harvest yield (kg), post-harvest hand cleaning (tree, ground fall, and machine; kg), and time of labor (min:sec).

Assumptions

In evaluating the economic feasibility of using a mechanical harvester, this study assumed that the production specifications (e.g., size of farm operation, density of trees per acre, trellis system, cider apple varieties grown, irrigation system, etc.) were the same as in the benchmark scenario, as well as most of the variable costs and fixed costs. The main differences were in the costs associated with mechanical harvest. The following details were used for the analysis:

1. A harvest crew is comprised of a driver and 2 stackers.
2. Post-harvest cleanup includes picking up fruit that bounces out of the harvester, picking fruit remaining on trees after the harvester passed over the row, and retrieving fruit left inside the machine; this is done by 2–4 people.
3. A mechanical harvester is rented for $120 per acre.
4. As mentioned above, the estimated total time of labor in mechanical harvest is 23% lower than the total time of hand harvest. Based on this, the picking rate for mechanical harvest is estimated at $64.54/bin (i.e., 77% of the baseline – $83.82/bin).
5. Picking efficiency of mechanical harvest is about 97% relative to hand harvest given the aforementioned yields of the two harvest methods. The remaining 3% represents those fruits that are extremely damaged.

Summary of Study Results

Since the production cost estimates in Galinato et al. (2014) represented 2013 prices, costs were adjusted by using the price paid indexes for production inputs in 2013 and 2015. Inputs of production include commodities, services, interest, taxes, and wage rates (USDA NASS 2016). A return of $337.50 per 900-lb bin or $0.375/lb for cider apples was used, which was the average price of cider apples in western Washington as of 2015. Hence, for the benchmark study involving hand harvest, the total cost of production and net returns in producing cider apples were estimated at about $13,307 per acre and $2,218 per acre, respectively.

Table 2 shows the side-by-side comparison of the costs and returns for the hand harvested and mechanically harvested cider apples during full production. Holding all else constant, study results showed that at 97% picking efficiency:

- Total harvest cost using a mechanical harvester was 22% lower than the hand harvest cost.
- Total production cost was lower than the baseline by 7%.
- The breakeven price required for 44.62 bins was about $277/bin, which was 4% lower than the breakeven price required for 46 bins in hand harvest.

To examine the sensitivity of profit, certain parameters can be changed, particularly crop yield that depends on the picking efficiency of the harvester, and the price of cider apples. Figure 1 shows that expected profit increases as crop yield increases, when other factors remain constant. Given total production costs, a 97% picking efficiency, and a price of $337.50 per 900-lb bin, the grower breaks even when yield is about 36.67 bins/acre (Table 3). On the other hand, a grower's profit will be equal to that of the hand harvested fruit ($2,218/acre) if the yield using a mechanical harvester is about 43.25 bins/acre.

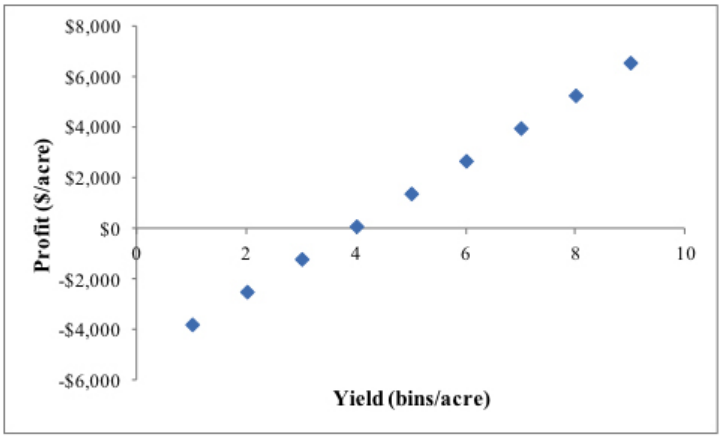

Figure 1. Estimated profit given different yields of cider apples during full production.

The differences in potential profit given different prices of cider apples and different picking efficiencies are illustrated in Figure 2. As expected, profit increases as the price of cider apples increases when other factors remain constant. Given total production costs, the grower breaks even when the price is approximately $344.19/bin ($0.382/lb), $319.85/bin ($0.355/lb), and $277.40/bin ($0.308/lb) at a picking efficiency of 74%, 81%, and 97%, respectively (Table 3). At 97% picking efficiency, the grower's estimated profit will be equal to the profit of hand harvested fruit if the price of cider apples is about $327.12/bin or $0.363/lb.

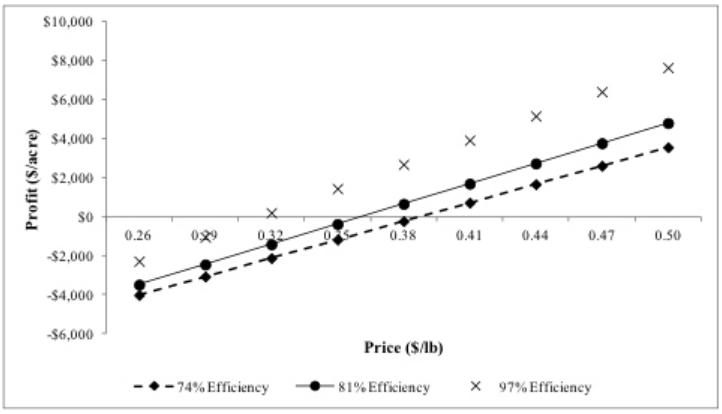

Figure 2. Estimated profit during full production given different prices of cider apples and different harvester picking efficiency.

Discussion

Typically, cider apples are picked by hand, but mechanized harvest can be a viable alternative with a few important caveats:

- *Yield threshold* – In mechanical harvest, savings in the cost of labor can be obtained but there is a threshold in the total harvest yield such that below this threshold, the net returns of mechanical harvest will be lower than hand harvest. During full production, the yield threshold is 43.25 bins which translates to a harvester's picking efficiency of 94% relative to hand harvest. At this rate, profit is equal to that of hand harvest.
- *Use of harvested fruit for cider making* – The study assumes that all mechanically harvested fruit are immediately pressed. Alexander et al. (2016) found that 100% of mechanically harvested fruit are bruised and 25% are sliced, and that this damage contributes to rotting and ultimately yield loss if fruit are stored at ambient temperature. About 22% of total yield can be lost to rotting if mechanically harvested fruit are stored at ambient temperature for two weeks. If cider apples will not be immediately used to produce cider, rotting can be mitigated by sorting the apples and utilizing cold storage, which will have additional costs.

Furthermore, the assumed rental cost for a mechanical harvester was based on the average cost of renting an over-the-row small fruit harvester. More information about the availability of harvesters appropriate for the cider apple orchard and the costs of harvesters would better help growers weigh their options regarding the harvest method to adopt.

Rental or purchase of used or refurbished harvesters will depend on the availability and affordability of the harvester, the size of the cider apple orchard operation, and the maintenance or augmentation of expected profit relative to hand harvest.

It must also be noted that the key results in this publication are based on assumptions for growing and hand harvesting cider apples in western Washington, and data from the WSU Mount Vernon NWREC proof-of-concept experiment that compare the yields and labor hours of the two harvest methods. Returns and production costs, including those associated with harvest, can vary for individual cider apple growers, thus the results cannot be generalized to represent the entire population of growers.

Excel Workbooks

Supplementary Excel Workbooks are provided for users interested in the underlying data of Table 2: Appendix A: Cost of Producing and Hand Harvesting Cider Apples in Western Washington; and Appendix B: Cost of Producing and Mechanically Harvesting Cider Apples in Western Washington. Appendix A follows the enterprise budget for western Washington (Galinato et al. 2014) and is adjusted to reflect 2015 prices. Most of the data in Appendix B are the same as in Appendix A; the only differences are the addition of the mechanical harvester's picking efficiency and mechanical harvest labor. Growers can modify select values in the Excel Workbooks to evaluate their own production costs and returns.

Additional Cider Research Information

NWREC is actively investigating cider apple production and mechanical harvest. The NWREC cider research orchard includes 60 specialty cider apple varieties. Figure 3 shows Brown Snout apples, a popular cider apple variety, grown at the NWREC orchard. The picture provides a preview of the tree architecture and crop load before harvest. Figure 4 shows the Brown Snout trees after mechanical harvest and Figure 5 shows Brown Snout apples being harvested by hand. Figures 6A and 6B show the over-the-row small fruit mechanical harvester in action in the proof-of-concept study. Figure 7 demonstrates the collection of the fruit by the mechanical harvester. More information about cider research at WSU and in the US can be found on the WSU Cider Research website.

Figure 3. Brown Snout variety is one of the cider apple varieties grown at the NWREC orchard.

Figure 4. Brown Snout trees after mechanical harvest.

Figure 5. Hand harvesting of Brown Snout apples.

Figure 6. Over-the-row harvester picking cider apple variety Brown Snout (A); fruit knocked off the tree by rotating drums (B).

Figure 7. Collection of fruit (A), conveyance of fruit (B), and delivery of fruit to bins (C).

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Table 1. Yield, labor and harvester efficiency.

Mechanical harvest	Yield (lb/acre)	Mechanical Harvester Efficiency	Mechanical Harvest Labor lower than Hand Harvest Labor
Hand harvest	11,741	-	-
Mechanical harvest			
1. Fruit picked by machine plus fruit left in ma	6,973	59%	65%
2. Plus fruit that fell out of the machine	9,018	77%	54%
3. Plus fruit left on the trees	11,624	99%	23%

Note: There are 680 trees per acre in the NWREC experimental orchard.

Table 2. Comparison of costs and returns of cider apple production during full production in western Washington using different harvest methods, 2015.

Costs and returns	Hand harvest	Mechanical harvest
Yield (bins/acre)[A]	46	44.62*
Price ($/bin)	$337.50	$337.50
Total Returns ($/acre)	**$15,525.00**	**$15,059.25**
Variable cost		
Fertilizer and chemicals[B]	$619	$619
Pruning, training and thinning	$1,900	$1,900
Other labor[C]	$807	$807
Harvest		
Picking[D]	$3,856	$2,880*
Harvester rental[E]	-	$120*
Other variable costs[F]	$1,233	$1,156*
Total Variable Cost ($/acre)	**$8,414**	**$7,482***
Total Fixed Cost[G] ($/acre)	$4,893	**$4,896***
Total Cost ($/acre)	**$13,307**	**$12,378***
Estimated Net Returns ($/acre)	**$2,218**	**$2,682**
Breakeven Return ($/bin)	**$289**	**$277**
Relative Picking Efficiency[H]		**97%**

Notes:

The main differences between hand harvest and mechanical harvest are marked with an asterisk (*).

A. Bin size is 900 lb. The yield in mechanical harvest reflects the picking efficiency relative to hand harvest.

B. Includes materials and labor.

C. Includes manual pest control, irrigation labor, frost protection labor, and general labor.

D. Picking at $83.82/bin (hand harvest); Picking at $64.54/bin (mechanical harvest), considering total harvest labor time is 77% that of hand harvest. Picking includes operation of the harvester, post-harvest cleanup of fruit remaining on the trees, ground fall, and fruit left inside the machine.

E. Approximate rental rate of an over-the-row small fruit harvester.

F. Includes irrigation water and electric charge, beehives, maintenance and repairs, fuel and lube, overhead and interest on operating capital.

G. The depreciation, interest costs of fixed capital and other fixed costs (miscellaneous supplies, land and property taxes, insurance cost, and management cost) are the same. The difference is in the amortized establishment costs that must be recaptured during the full production years, calculated as: accumulated establishment costs in Year 5 amortized at 5% for 21 years.

H. Calculated as total yield harvested by machine divided by total yield harvested by hand. Total yield includes post-harvest cleanup (remaining fruit picked from trees, ground falls, and fruit left inside the machine). The remaining 3% represents those fruits that are extremely damaged.

Table 3. Estimated costs and returns by harvest method.

Harvest Method	Yield (bins/acre)	Price ($/bin)	Mechanical Harvester Efficiency	Total Returns ($/acre)	Total Cost ($/acre)	Net Returns ($/acre)	Breakeven	
							Yield (bins/acre)	Return ($/lb)
Hand harvest	46.00	$337.50	-	$15,525.00	$13,306.80	$2,218.20	39.43	$289.28
Mechanical harvest								
1. Fruit picked by the machine plus fruit left in the machine	34.04	$337.50	74%	$11,488.50	$10,372.19	$1,116.31	30.73	$304.71
2. Plus fruit that fell out of the machine	37.26	$337.50	81%	$12,575.25	$10,831.68	$1,743.57	32.09	$290.71
3. Plus fruit left on the trees	44.62	$337.50	97%	$15,059.25	$12,377.74	$2,681.51	36.67	$277.40

Notes:

Bin size is 900 lb.

The yield of the mechanical harvester depends on the picking efficiency.

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