Innovations in Mechanical Harvest for Cider Apples

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Cider, also referred to as 'hard cider,' is fermented apple juice and is the fastest growing segment of the liquor industry in the U.S. today. There was a 65% increase in production each year from 2008 to 2014; in 2008, 2.3 million liters of cider were produced and this increased 30-fold to 69.3 million liters in 2014. There is a need to develop cost effective, efficient, and high yielding orchard systems to supply fruit for the expanding cider market in the U.S.

The cost of hand harvest of cider apples accounted for 30% of the total annual orcharding costs in a study in western Washington. This result indicates that reducing harvest costs could improve profitability of cider orchards in the U.S. In this two-year study (2011 and 2012) we compared a mechanical over-the-row 'shake and catch' small fruit harvester to hand harvest for cider variety 'Brown Snout' grafted onto Malling 27 (M.27) and East Malling/Long Ashton 9 (EMLA9) grown on a low trellis. We compared weight of harvested fruit, labor hours for harvest, tree and fruit damage, and fruit and juice quality characteristics for machine and hand harvest.

Methods

The orchard for this study was established in 2002 at Washington State University Northwestern Washington Research and Extension Center (WSU NWREC) at Mount Vernon. 'Brown Snout' cider apple was planted at 16-ft between-row and 4-ft in-row spacing. Orchard planting density was 680 trees per acre. Between-row spacing was wider than commonly used in commercial orchards to accommodate potential unknown needs for mechanical harvest. Trees were trained to a three-wire trellis system with post height of 6.5 ft. The lowest wire was 2 ft above the soil surface to accommodate the catch plate of the mechanical harvester. In 2011, tree limbs were attached tightly to the trellis wires and were pruned to maintain a narrow canopy, whereas in 2012 limb attachment to the trellis wires was loosened and pruning was adjusted to widen the canopy so that the harvester shaker bars could more readily shake the fruit off the trees.

Fruit was harvested when fully ripe, on 25 Oct. in 2011 and 17 Oct. in 2012. Hand harvest was done by four unskilled agricultural workers who were not specialized in apple picking. Machine harvest was done with an over-the-row small fruit harvester (model OR0012; Littau Harvester, Lyndon, WA) operated by an experienced harvester driver. In addition, two unskilled agricultural workers moved fruit from the machine harvest belt into totes on top of the harvester. Hand harvest plots were picked first, then respective plots were picked with the machine harvester.

All ground falls were first removed from the orchard. For hand harvest plots, fruit were picked from trees and any fruit that fell to the ground during picking were picked up and included in the total yield, following common grower practices as groundfalls can be used to make cider. For machine harvest plots, fruit was harvested with the over-the-row harvester, and the fruit weight was recorded. All fruit remaining on trees following machine harvest as well as fruit that fell to the ground during harvest were picked and weighed together, and were considered to be clean-up fruit weight. The number of labor-hours required to pick each plot was recorded, and the cost of

labor per acre was calculated based on wage rates paid by local growers for similar work: $18 per hour for hand harvest and fruit handling on the mechanical harvester, and $22 per hour for driving the harvester (both rates included applicable taxes and benefits).

Both years, one box of fruit per plot was assessed immediately after harvest. For stored fruit, one box per plot was assessed after 3 weeks of storage in 2011, while in 2012, one box per plot was assessed after 2 weeks of storage and one box per plot was assessed after 4 weeks of storage. Fruit were stored in the same facility both years at 32 ^{o}F. Each box of fruit was milled and pressed in a basket cider press. A 500 mL sample was collected from the juice of each plot, placed in a plastic bottle, and frozen (5 ^{o}F) until all samples had been pressed. Juice samples were then thawed to room temperature (74 ^{o}F) and assayed for soluble solid content (measured by Brix), pH, specific gravity, titratable acidity, and tannins.

Results and Discussion

There were significant differences between years for most of the parameters measured, however there were no significant differences due to rootstock or interactions between year and rootstock for any of the parameters measured. On average, harvest weight was 11,319 lb per acre for hand harvest and 7,812 lb per acre for machine harvest, a mechanical harvest efficiency of 70%. When weight of fruit that was left on trees or fallen to the ground after machine harvest (clean-up fruit weight) was added, mechanical harvest weight increased to 9,998 lb per acre overall, and harvest efficiency increased to 88%. A training system more like a fruiting wall may optimize fruit yield with an over-the-row 'shake and catch' harvester. Netting could be added to the front and back of the harvester to prevent fruit from bouncing out after it drops onto the catchplate. Yield of 'Brown Snout' was reduced because tree density in this study (680 trees per acre) was 38% lower than the recommended density for a similar training style (1100 trees per acre). Additionally, tree height was low (6.5 ft) to allow the machine harvester to pass over the row, and this further limited yield. An over-the-row machine harvester for trees that are 10-12 ft tall would be a better option to optimize apple yield.

The number of labor-hours per acre for hand harvest was eight times greater than for machine harvest in 2011 and was two times greater in 2012. Hand harvest labor-hours were three times greater in 2011 than in 2012 due to heavier fruit set and higher yields in 2011. On average for the 2 years, hand harvest required 23 labor-hours per acre while machine harvest required 5 labor-hours per acre. Generally, the 2-year average cost per acre for harvest labor was four times greater for hand harvest ($417) than for machine harvest ($93). In this study, harvest was done by general orchard workers and not by experienced fruit pickers. The number of labor hours for hand harvest with an experienced apple picking crew would likely be less than the number measured in this study, while the number of labor hours for machine harvest would likely be similar.

There were no significant differences due to harvest method for Brix, pH, specific gravity, titratable acidity, or tannins of fruit pressed immediately after harvest or after 2 to 4 weeks storage. When fruit was pressed after storage (3 weeks in 2011, 2 and 4 weeks in 2012), Brix and specific gravity of juice increased as compared to juice pressed immediately after harvest both years. For fruit that were stored, pH of juice tended to decline both years (0.01 pH units in 2011, 0.06-0.12 pH units in 2012), however this difference was significant only in 2012. Changes in

juice sugar content and pH with storage followed expected trends, as starch breaks down into sugars, sugars become more concentrated due to dehydration, and fruit acidity increases due to respiration during storage. Machine harvested fruit were bruised and some fruit were also sliced and cut. Where fruit is stored outside or in open barns for up to 1 month before pressing ('sweating'), cut and sliced fruit are more prone to rot which causes off-flavors in the pressed juice. A current study is underway to assess fruit quality when mechanically harvested fruit are stored under ambient barn conditions.

The cost of an over-the-row harvester varies depending on manufacturer, year, model, wear-and-tear (if used or refurbished), and location. In general, cost ranges from $70,000 for used, refurbished models in good working order to $225,000 for a new custom built model. More information is needed to determine economic feasibility of over-the-row mechanical harvest of cider apples.