PennState Extension

Harvest-Assist Platforms for Apple Growers

Apple harvesting is a labor-intensive work accomplished manually and typically by seasonal pickers.

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During harvest, apples are picked, collected into a bucket, and then carefully dumped into a nearby apple bin. Ladders are required to reach the fruit from the top portion of trees, which can slow harvesting efficiency and potentially be hazardous.

Harvest-assist platforms may be used to improve harvest efficiency and eliminate ladder usage for pickers. Typically, two or four pickers stand on the platform facing the trees to pick fruits from the sides. The use of harvest-assist platforms in orchards can be traced back to the 1990s, and there is a wide range of harvest platforms on the market today (Courtney, 2018). This article will introduce a few harvest-assist platforms and review the results of a couple of research studies.

Harvest-Assist Platforms With Bin Handling System

Typically, a harvest-assist platform includes a self-propelled driving vehicle, a fruit delivery system, a bin handling system, and decks for pickers to stand on. Transporting the picked fruit into a bin is an important step for these platforms. Different transport methods have been adopted in current harvest-assist platforms, including 1) the use of a traditional picking bucket emptied into a bin on the platform, 2) the use of a vacuum system to transport individually harvested fruit to the bin, and the use of a conveyor belt in a similar manner. Two popular systems in use are the Bandit Xpress and the Bandit Cyclone.

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Figure 1. Two current harvest-assist platforms used in the U.S. orchards. Left: a Bandit Xpress platform. Right: a Bandit Cyclone vacuum harvester.

The Bandit Xpress is a basic Bin Bandit harvest-assist platform from Automatic Ag Systems (Moses Lake, WA) with platforms to support four pickers: two in the front and two in the rear. One level is positioned lower than the other to enable pickers to harvest from different bands in the tree canopy. The Bandit Xpress is particularly adept for those orchards with narrower plantings. LED lights mounted on posts enable picking at night. There are a couple of other models of this type, including the Bandit Cub and the Bandit Super Cub, all of which are from Automated Ag. Bin Bandit products generally rely on bringing the bin closer to the pickers. The advantage of this is the flexibility it gives pickers in terms of moving around the platform to where the high volumes of fruit are.

The Bandit Cyclone is a vacuum harvester from DBR Conveyor Concepts, LLC (Conklin, MI). The chassis is a self-propelled Bin Bandit platform with a center-mounted vacuum and fruit distribution system. As with the Bandit Xpress, a crew of four pickers stands on the hydraulic platform picking fruit from trees up to 13-14 feet.

With this system, a padded receptacle and foam-lined vacuum tube replace the picking bag. Pickers carefully place each apple into the receptacle, and the strong vacuum whisks the fruit away at twelve feet per second. As it nears the end of the vacuum tube, deceleration wheels with foam-lined pockets reduce the fruit's velocity and gently place it on a distribution wheel that settles the fruit, bruise-free, evenly in the bin. From an on-platform harvest perspective, the pickers are continuously positioned near the tree canopy; there is no need to leave the worker's station to empty a picking bag.

Based on field observations, platforms improved picking efficiency greatly. For ladder picking, it was found that the time used for picking ranges from 60-70%, with the remaining time used for ladder setup and mounting/dismounting, walking to the bin, and dumping fruits into the bin. For picking on a Bandit Xpress, the distance to travel to the bin is reduced, and although no ladder work is necessary, interruptions to harvest occur each time the bag needs to be emptied. With the Bandit Cyclone, the only disruption to harvest occurs during bin changing since there is no storage for the fruit until an empty bin has been seated. Tables 1 and 2 show two preliminary test results of the two harvest-assist platforms compared to picking with ladders.

Table 1. Preliminary test results for Bandit Cyclone platform in Michigan in 2019.

	Ave. time per bin	Other collected data
Bandit Cyclone	13.1 minutes	Bin changing: 2.14 minutes (Ave. per bin) Row changing: 3.75 minutes (Ave. Per row)
Ladder picking	21.0 minutes	Pre-placed bins. Picking time: ~60% of overall time. Non-picking time (walking to bin, dumping, and setup ladder): ~40% of overall time

Table 2. Preliminary test results for Bandit Xpress platform in Pennsylvania in 2021.

	Ave. time per bin	Other collected data
Bandit Xpress	12.9 minutes	Bin changing: 0.9 minutes (Ave. per bin). Row changing: 2.87 minutes (Ave. per row)
Ladder picking	28.2 minutes	Following a bin trailer. Picking time: ~71% of overall time. Non-picking time (walking to bin, dumping, and setup ladder): ~29% of overall time

This research makes it impossible to compare the two machines directly since they were observed in different orchards at different locations. Many things may influence picking efficiency. Harvest efficiency from these platforms depends on the density of fruit on the trees, the distribution of the fruit in the tree, and the crew's skill, all of which influence the speed at which the platform can progress down the row.

Based on trials at Automated Ag, it takes ten seconds to empty the collection bag into the bin on the Bandit Xpress. Using an estimated 25 bags per bin, the Bandit Cyclone with vacuum should save four minutes of filling time for each bin. When considering worker fatigue, the collection receptacle and harness weigh less than a full picking bag, reducing pressure and muscle strain on workers' shoulders.

Another benefit of the Bandit platforms is that the base platform of the machines can be used for other off-season purposes, such as winter pruning, training, and hand thinning.

Harvest-Assist Platform Based on the Fruit Distribution

Typically, for harvest-assist platforms, the heights of the standing decks are pre-set by the operator based on the tree height to ensure coverage of the whole tree canopy by the pickers. While in operation, each worker should have fruit found inside a "canopy zone," which is only fruit within a reachable range. However, fruit distributions are non-uniform, and worker picking speeds vary. Furthermore, based on our observations, workers stationed at the leading end of the platform tend to be rather zealous and over-pick the fruit (pick outside their "zone"), leaving fewer fruit for the aft workers to harvest.

These conditions generate a mismatch between labor demand (incoming fruit rates) and labor supply (fruit picking rates) in each zone, and this mismatch limits platform-based harvesting efficiencies. To address this issue, a crop load-based harvesting system was developed by UC Davis engineers (Fei and Vougioukas, 2021).

Figure 2 shows the overall structure of this type of harvest platform. As the platform travels forward, it estimates the incoming fruit distribution using a computer vision system, measures each worker's picking speed using instrumented picking bags, and controls the heights of hydraulic lifts that move workers up and down. An algorithm was developed to maximize the machine's harvesting efficiency by adjusting the platform elevations to match the crop load and the pickers' harvest rate. Experiments were performed in a commercial orchard to compare fixed height with variable height platforms. The fixed zone platform averaged 298.8 kg/h (658.7 lb/h) throughput, while the variable-height platform throughput was 327.6 kg/h (722.2 lb/h). This represents an increase of 9.5%.

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Figure 2. Apple harvest-assist platform based on fruit distribution by a machine vision system (University of California, Davis).

In-Field Sorting System for Harvest-Assist Platform

No commercially available harvest platform currently utilizes harvest-time or "in-field" sorting. Previous research has shown that in-field sorting may reduce postharvest costs and economic losses, especially when a high percentage of culls are present in harvested apples. Engineers at Michigan State University and USDA ARS proposed a technology that integrates harvest-assist and in-field sorting (HAIS) functionalities (Lu et al., 2021). The system includes adjustable picking platforms with fruit receiving conveyors, a computer vision-based grading and sorting system that is capable of sorting apples for color and size at a speed of up to twelve apples per second, an automatic bin filling system for discharging graded fruit to bins, and a computer-controlled hydraulic system for automatic handling of empty and full bins. Fruits on the conveyors are then transported to a specially designed fruit singulating and rotating device, separating and rotating the fruit as they move forward. After the fruit enters the computer vision chamber, a color digital camera automatically acquires multiple images of the fruit. Eventually, this machine can sort apples into two quality grades, fresh and processing, into separate bins.

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Figure 3. Apple harvest assist platform with in-field sorting system (Michigan State University and USDA ARS).

Compared to ladder picking, harvest-assist platforms have greatly increased apple harvesting efficiency. Meanwhile, onboard fruit handling systems, including vacuum fruit transportation and in-field sorting, could bring more benefits using harvest-assist platforms.

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