Rural Migration News

Blog 267

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Ag Automation

A Global Harvest Automation Report (GHAR) released in February 2022 found that fruit and vegetable farmers expect a third to two thirds of their pre-harvest work to be automated by 2025, but they foresee slower mechanization of harvest tasks. The report emphasized that mechanizing farm tasks now done by hand is hard, as indicated by the fact that three fourths of ag tech startups have not yet generated revenues. Most ag tech startups have fewer than five functioning prototypes and fewer than 10 paying customers.

Most of the farms surveyed for the GHAR produced fresh fruits and vegetables. Two-thirds invested $350,000 to $400,000 a year to automate hand tasks, purchasing equipment that eliminates pre-harvest jobs and makes hand harvesters more productive, as when platforms replace ladders or robots and conveyor belts reduce the time that workers must carry harvested produce.

Fruiting Walls Make it Easier to Find and Pick Ripe Apples

Labor-saving mechanization and automation is motivated by the rising cost of farm labor. Average farm earnings of $15 an hour were 60 percent of average $25 an hour nonfarm earnings in 2020. The farm-nonfarm wage gap is expected to narrow as farm earnings average $20 in 2025 and nonfarm earnings $30.

Mechanization

Harvesting is the most labor-intensive and hardest to mechanize phase of producing most fresh fruits and vegetables. Harvest labor costs are often a third or more of production costs.

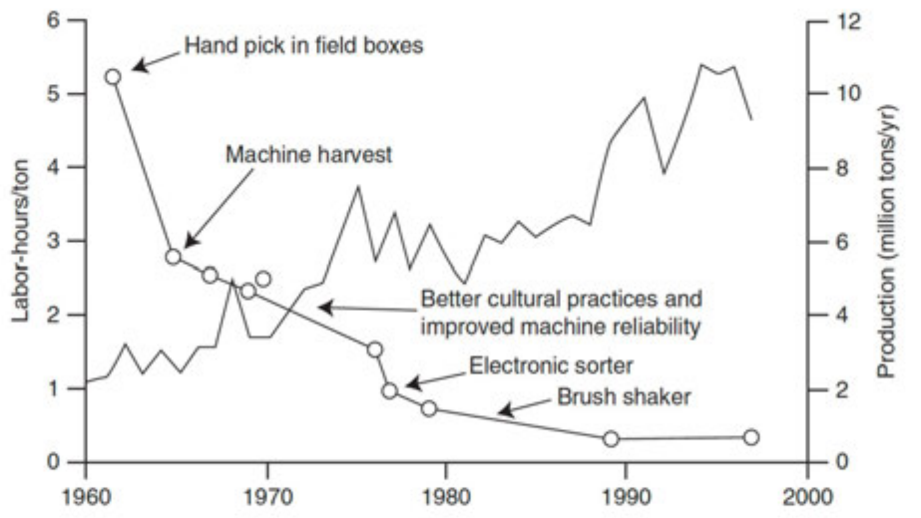
Most ag tech startups aim to mechanize a particular task now performed by hand, and focus on tasks that are performed in many crops. This means that more startups develop machines to detect and remove excess plants and weeds, a pre-harvest task, than on machines to harvest only apples or iceberg lettuce. The exception may be controlled environment agriculture facilities such as greenhouses that build automation into their design to produce and harvest a particular fruit or vegetable.

There are two general rules about harvest mechanization:

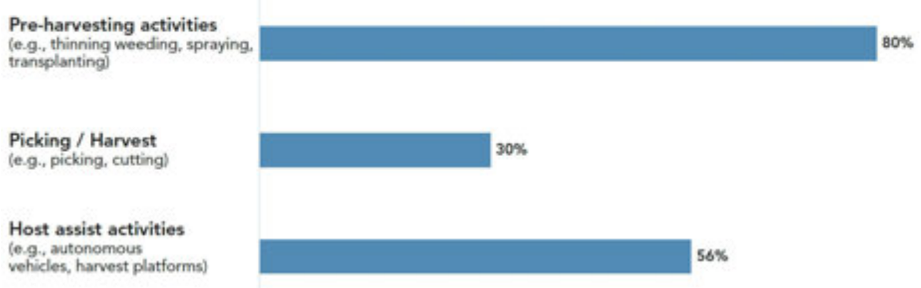
- Once-over harvesting is easier than selective harvesting that involves multiple passes through the field or orchard
- It is easier to mechanize commodities destined for processing than those that are sold fresh to consumers, since processors freeze, can, or dry crops soon after harvest and are less worried about blemishes or internal damage.

Most vegetables are annual plants, so machines can harvest root vegetables such as potatoes in one pass through the field, destroy the plant,

Processing Tomato Production Increased with Harvest Mechanization in the 1960s



80% of Growers Invested in the Automation of Pre-Harvest Activities, and 55% in Harvest Assist Devices, but Only 30% in Harvesting



remove the dirt, and convey the crop to trucks. Shake-and-catch harvesters grasp tree trunks or limbs and deliver a jolt to dislodge fruits and nuts into a catching frame or to the ground for later pickup.

The most difficult crops to mechanize are those that are fragile and require selectivity due to multiple passes through the field or orchard. Machines must be able to rapidly detect and harvest mature produce without damage to the harvested fruit or vegetable, the immature produce still on the plant, and the plant itself. It is hard to develop machines that can distinguish ripe from unripe commodities, select the ripe without damage, and perform these steps as quickly and cheaply as human hands.

Mechanizing the harvest of a crop often requires a systems perspective, cooperation between researchers in biology and engineering, and trial-and-error refinements. A systems perspective reimagines the entire production process, perhaps replacing three-dimensional round apple trees spaced far apart with dwarf trees planted close together and whose limbs are trained to grown on trellises. The resulting fruiting walls make it easier to identify ripe apples and reduce the distance that apples fall if they are removed from the limbs mechanically.

A systems perspective may mean the development of new varieties of fruits and vegetables that are planted in different ways and handled differently. For example, machine harvested produce may include more immature or damaged fruits and vegetables that must be separated in packing and processing facilities, as with blueberries harvested by machine.

The second key to mechanization is cooperation between scientists and engineers to change plant behavior and to develop machines to prune, thin, and harvest plants and trees. Scientists normally breed plants to maximize yield, resistance to disease, and taste. However, to facilitate mechanization, plants may have to develop uniformly ripening fruits and vegetables of a size and shape that makes them easier to harvest.

The third key is trial-and-error refinement, since laboratory studies and prototype machines rarely work as planned under field conditions. The diffusion of successful mechanization systems often follows an S-shape, beginning slowly with pioneers, accelerating rapidly, and leveling off at almost 100 percent adoption.

Systems, cooperation, and refinement were key to mechanizing the harvesting of processing tomatoes after the Bracero program ended in 1964. Mexican Braceros were almost three-fourths of the hand-harvest workforce, and most observers believed that several decades would be required to develop uniformly ripening and oblong tomatoes, a machine to harvest them, and changes to the processing plants to handle machine-harvested tomatoes. However, farmers bought equipment and specialized in growing processing tomatoes that were hauled to processors in 12.5 ton loads, and fewer and larger farmers produced more processing tomatoes with fewer workers within a decade.

Public policies played key roles to accelerate the mechanization of the processing tomato harvest. Ending the Bracero program created a need for mechanization, tax monies funded biological and engineering research at UC-Davis, and state-run testing stations determined the quality of truckloads of tomatoes headed for processing plants. The result was a controversy over spending public funds to benefit larger growers and processors that, combined with rising unauthorized migration in the 1970s and 1980s, slowed publicly funded mechanization research.

Automation

Private firms have taken the lead to develop machines that replace hand labor in US agriculture. Most private firms tackle tasks that promise the largest market for their machines, so there are more efforts to refine precision planting and to automate weed and pest control rather than to develop a machine to harvest a particular crop such as asparagus or green onions.

The most common ag tech startup develops devices to give growers more information about their crops by testing the soil to determine plant water and nutrition needs or monitoring crop size and quality.

Startups that develop technologies to replace hand workers have made most progress on pre-harvest tasks, such as reducing the need for hand-weeding crews, and on harvest assist tasks, such as conveying harvested produce from pickers to collection points.

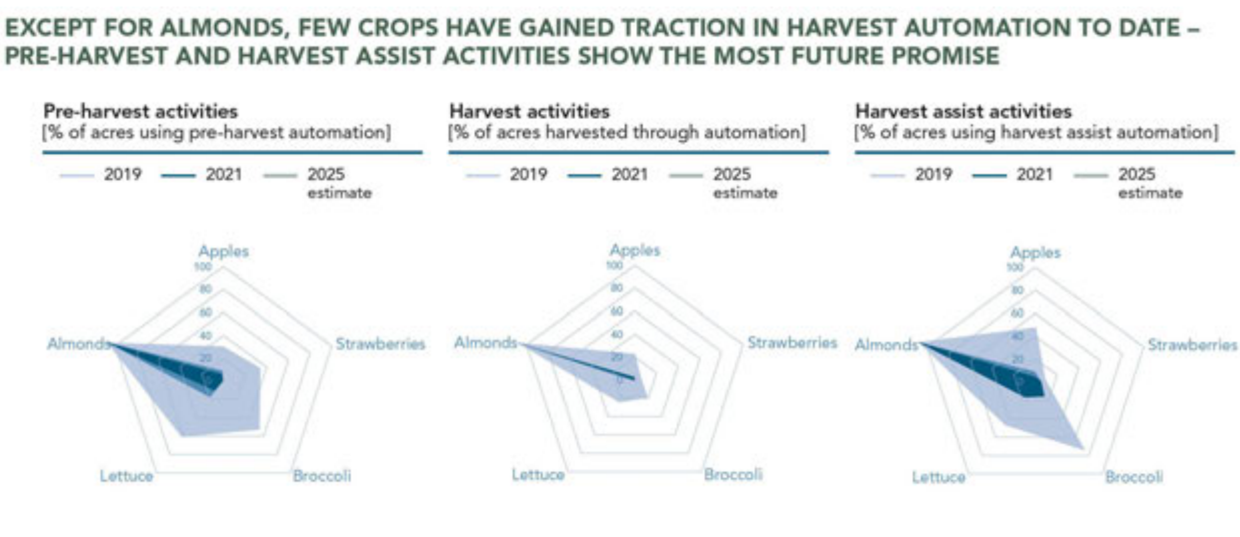
The GHAR summarized the status of automation in five commodities anchored by almonds, where pre-harvest and harvest activities are mechanized. The shaded areas of the figure highlight the percentage of the crop's acreage that is farmed with automated methods and shows that pre-harvest tasks are more automated in broccoli and lettuce than in apples and strawberries. There is little harvest mechanization in any commodity except almonds, but harvest assist devices are common in broccoli and lettuce.

A comparison of the status of mechanization in six leading crops highlights (1) the challenges to harvesting many fresh fruits and vegetables by machine and (2) the mechanized production of almonds. Apples are the most valuable US fresh fruit, and growers who want to sell fresh apples to consumers pick them by hand to maximize pack outs and prices. Platforms that replace ladders make the workers who prune, thin, and harvest apples more productive, and are used on a rising share of fresh apple acreage in WA state.

Almonds are at the other end of the automation spectrum, with pre-harvest and harvest activities fully mechanized. Smaller almond trees begin to yield almonds sooner, and these shorter trees that are planted close together are easier to prune with top and side saws that remove excess growth. Almonds are shaken from trees, swept into rows, and picked up by machines.

Blueberries, strawberries, and lettuce are largely hand harvested. Machines are available to harvest blueberries, but they permit only one pass through the field and increase damage to the fruit, which reduces the pack out rate or the share of the crop that can be sold fresh to consumers. Almost all strawberries are hand harvested, but many growers place conveyor

Harvest Assist Devices are More Common than Harvesting Machines



Source: Grower survey, Western Growers, Roland Berger belts in front of pickers that accept full flats, enabling workers to pick more flats per hour.

Baby-leaf lettuces are harvested by lawn-mower machines, and some romaine heads of lettuce are harvested by machines with water jets that cut the heads and convey them to bins for transport to packing plants. Almost all large lettuce growers have conveyor belts that travel in front of hand harvesters, allowing crews to pick more heads of romaine or iceberg lettuce.

The GHAR noted that markets for many of the complex machines needed to harvest a particular fruit or vegetable are small, so that even a large profit per machine may not be attractive to investors. Many manufacturers of specialized harvesting machines are in Europe, Japan, and Australia and New Zealand, where farm wages may be higher than in the US.

Diffusion

Rising labor costs encourage farmers to adopt labor-saving machines, but most want reliable machines that justify the cost of the machine within a few years of adoption. Some large producers of fresh fruits and vegetables have in-house R&D departments to develop or adapt technology to automate harvesting, which can slow the collaboration between researchers that could speed automation if each firm aims to sell its harvesting machine to rival growers.

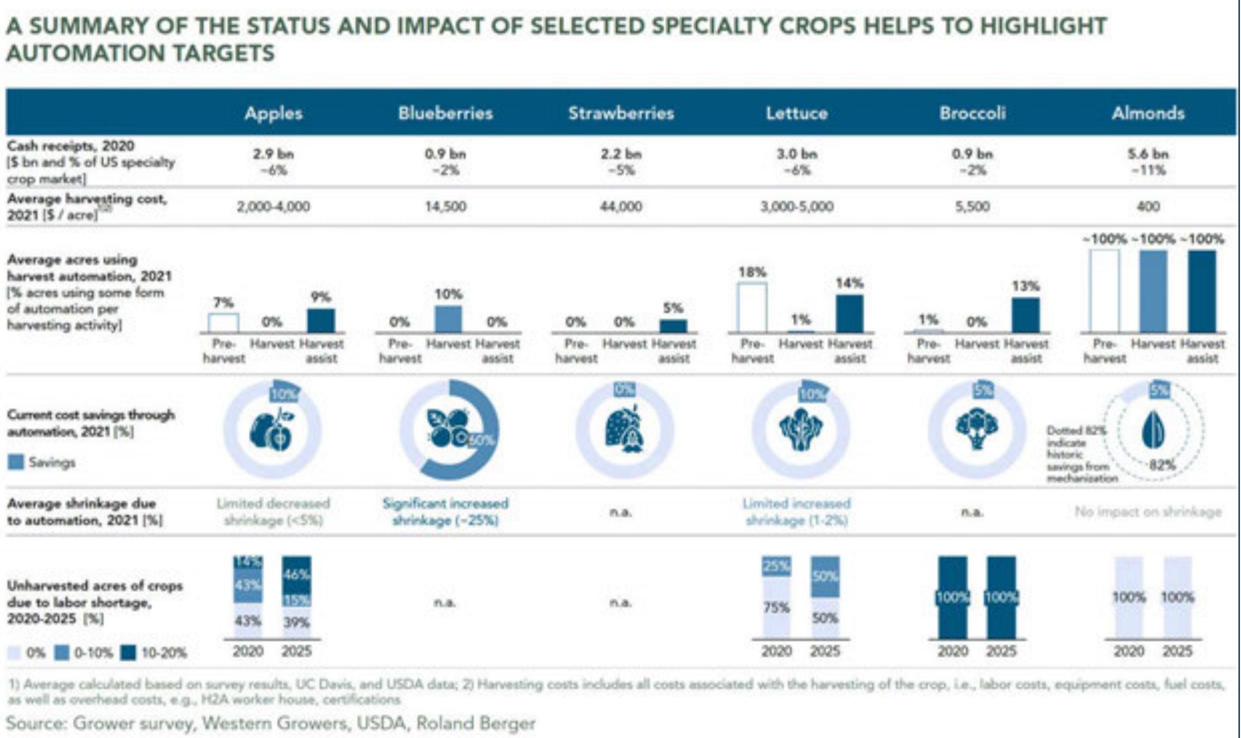
The GHAR emphasizes that the most mature automation projects deal with pre-harvest activities such as planting, thinning, and weeding. The second leading focus is on harvest-assist devices that make hand workers more productive.

Harvest mechanization usually involves a machine tailored to one commodity that can locate ripe fruits and vegetables and harvest them without damage to the commodity or to the plant and immature crop. The GHAR survey of ag tech startups found that four had more than 10 paying customers for their prototype machines:

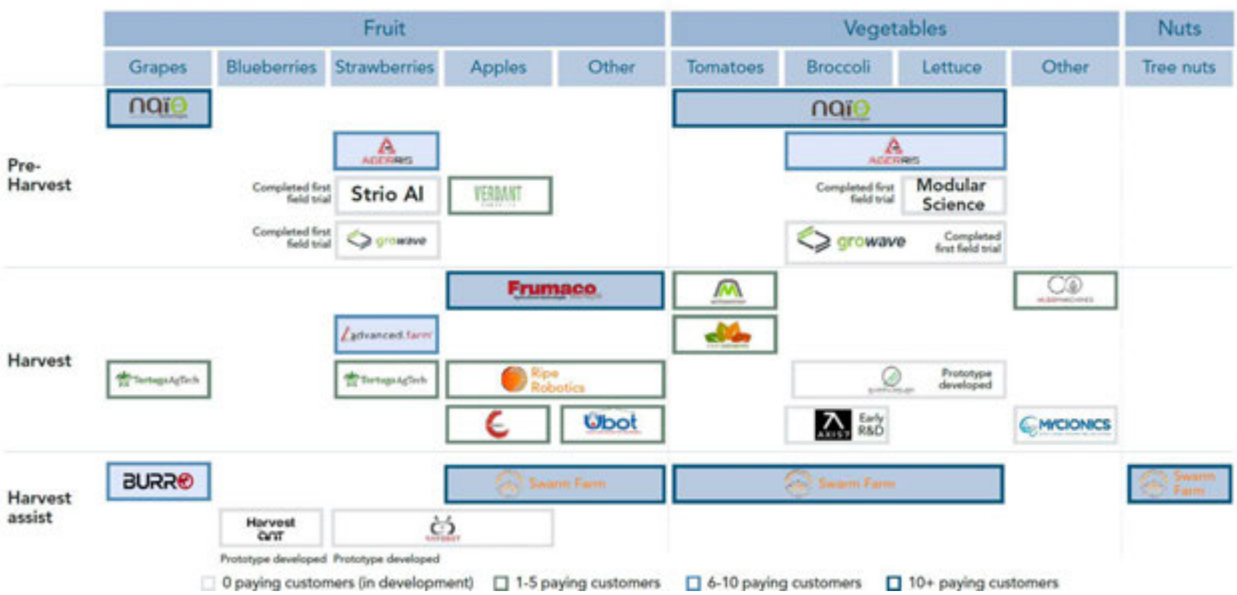
- Naïo Technologies is a French manufacturer with 230 robots that weed fields. Naïo sells robots or offers weeding as a service to growers
- Frumaco is a German manufacturer of fruit pruning, thinning, and harvesting machines
- Philadelphia-based Burro had 90 harvest-assist robots in operation in 2021 to carry tubs of table grapes from harvesters to packers at the end of rows; one robot can serve six to eight harvesters
- Swarm Farms is an Australian manufacturer of agricultural robots that spray and weed crops

The GAHR emphasizes that only a few of these startups have a significant number of machines in fields and orchards.

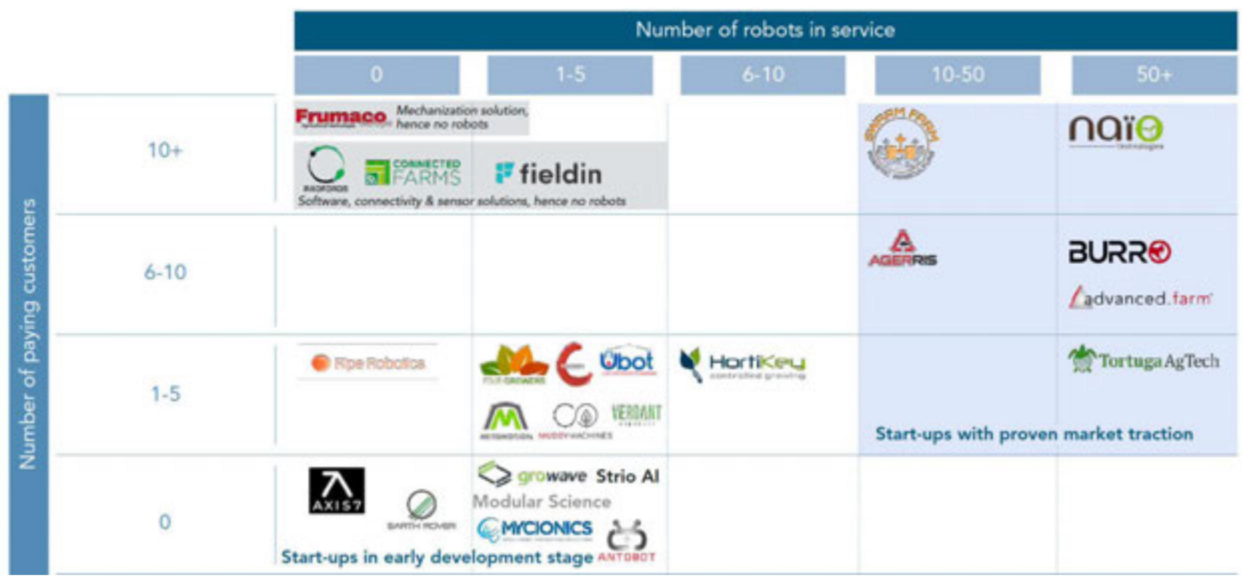
The $6 Billion U.S. Almond Crop is Fully Mechanized, but not the $3 Billion U.S. Apple Crop



4 Startups had More than 10 Paying Customers for Their Ag Automation Devices



5 Ag Startups have Robotic Devices that are Sold to Farm Customers



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