

WTFRC Technology Roadmap

Trends and Barriers to Technology Adoption



Industry and Technology Adoption Trends & Barriers

Trends in Washington Apple Production

Broad Trends

The industry is currently going through a down cycle. The current cycle of low prices in the apple sector is not unprecedented, but is also not common in the history of apple production. There are many likely drivers, but a key result is that, though growers are particularly hungry for cost-saving tools now, they are likely also more risk averse than they might be during an era of rising apple prices.

Labor costs continue to rise. Between the wage rate for H2A workers and the additional expenses related to housing and transit, grower expenses related to labor are some of the highest in the US, and growing at a rate of about 6% per year. Additionally, regulatory requirements to ensure worker safety are increasing. One grower reported spending more than \$17 million in the last two decades on housing, shuttles, and administrative staff alone. Plus, given the level of the minimum hourly wage, growers are finding it difficult to set a piece rate that motivates increased productivity.

Voices of the Industry

"Global GAP and other regulations, along with rising expenses and wages, are making it harder to stay in business"

–Washington Apple Grower

"The number one issue is labor efficiency / cost management. 65% of the production cost is labor. Businesses in the state of Washington no longer have control of the cost structure of labor, so the only long term solution is to dramatically reduce the headcount of field workers."

- Industry Service Provider

Increased competition within Washington State. The entrance of outside investors into the apple production space in Washington has led to a substantial increase in overall apple production despite the labor and input cost headwinds. This increase, combined with a more challenging export market (US apple exports are off 8 million boxes in 2023), have made for a poor price environment for producers, especially of the most common varieties (Gala, Fuji, and Granny Smith).

Consolidation. Due to a range of factors, from generational transition and access to capital to rising costs, there are fewer, larger producers today than previously. Similarly, the industry has seen increased interest from outside capital sources, e.g., private equity.

Increasingly challenging regulatory environment. Across areas such as food safety, export (phytosanitary conditions), and labor access (particularly through the H2A program), compliance costs are rising which will in turn require increasing amounts of data to manage.

Increased climate volatility. While attribution and names for this vary, and are often politicized, there's recognition that climatic conditions are increasingly volatile and this has associated risks for apple production.

Apple Production Trends

Input inflation cuts into margins. Today, from the moment an apple orchard is first imagined until the time of its first harvest, growers will spend about \$65-\$70,000 per acre. After that, even leaving aside labor, costs related to crop chemistry, equipment, energy, and other essential inputs will mean the orchard won't begin paying for itself for about 15 years. Some of these factors (like land cost, etc.) are part of longer trends, but others (like crop chemicals), are beholden to volatile markets in which prices fluctuate substantially over short periods of time, significantly increasing grower's price risk.

Newer orchard designs opt for uniformity and 2-dimensionality. Across grower interviews, we did here a near uniform story about a movement towards increased standardization, uniformity, and 2-dimensionality in orchard plantings, in preparation for autonomous equipment that operates primarily by looking at a "wall" and picking the fruit that it can clearly see. Vertical trellises seem to be much more accessible (compared to V trellises) to autonomous equipment, and despite the cost disadvantage, there is a trend towards having a more mixed system to be prepared for mechanized solutions when they come available. Equipment manufacturers and orchard managers are also largely aligning on other key features, like on equipment size that fits the majority of row/tree spacings and bin sizes.

Aging population and the need to make wisdom available to young growers. With an aging population of growers in the Washington apple space, there is increased interest in making more wisdom and expertise available for younger growers, especially when it comes to horticultural issues. An experienced grower can look at a tree and determine its need for more/less water, nutrients, etc., based on decades of experience, whereas younger growers have a harder time making similar evaluations.

Production Technology Trends

Steady tech progress has been made in many areas of apple production. Growers say there have been regular and meaningful improvements in areas of fruit quality, root stock, IPM and nutrients, chemical thinning tools, and varieties, among other things. Though there is still room for marginal improvement in specific areas, there are few gaping holes in technological progress outside the labor space. Significant ROI has been realized by some related to moisture monitoring, plant health/tree stress monitoring, irrigation monitoring, and payroll management software.

More data without the ability to act on it. Many growers noted that there has been a proliferation of tools to help them identify parts of the orchard that are experiencing adverse effects, but there have been far fewer cost-effective tools to facilitate variable rate application of inputs. Also, many of these tools do not deliver the data within a reasonable time frame in which it can be acted on.

Advances made in monitoring/mapping for intensive orchard management. There are existing solutions that are being adopted to improve labor efficiency, such as scanning technology that can help in managing labor during pruning and thinning. Multiple growers are also currently using a semi-custom solution to track and analyze this data. Though affordability is increasing, the current barriers are high costs per scan and a too long turn-around time. Access

to high upload/download speeds was also mentioned as a potential barrier to widespread adoption going forward.

Barriers to Current/Future Technology Adoption

Declining profitability of production. An existential barrier, the fact that orchard profitability is such a high hurdle to clear likely means that any tech that requires significant upfront expense or that has a long payback period will be untenable for some major cohort of Washington apple growers. Service-based go-to-market models (e.g., custom harvest with a price per bin rate) will likely be more widely adopted than equipment or tools that must be bought outright.

Lack of uniformity across the apple sector and over time. Growers in the apple sector are a relatively heterogeneous group, and even a single organization will go through periods, within years and between years, in which they operate outside of their standard operating procedures. Plus, each grower has some elements of unique management practices and/or orchard architecture (e.g., row spacing, tree spacing, trellis system, bin size, irrigation system, etc.) meaning that even similarly sized orchards in the same year might operate quite differently. Because of this lack of standardization, efficiency and affordability calculations for a technology or service will vary for different growers in different years.

Specific examples include:

- Some years, it may make sense for growers to absorb a 10% fruit loss related to mechanical harvesting, other years, it may not.
- Some growers have access to senior water rights along the Columbia River while others do not, and therefore have much higher concerns about water availability from year to year compared to other factors.
- Depending on the compensation that exists on a given farm, benefits to improved labor efficiency gained from platforms may accrue to the grower, or to the picker.
- Tools like robotic sprayers and mowers are available and, in some cases, affordable today; however, small operations, or operations made of non-contiguous, small orchards, can't take advantage of these tools due to affordability constraints.

Upfront cost efficiency. In the past, technology tools that have been available in the earliest stages of their development have not yet been cost efficient. This kind of technology might be worth trialing, but meaningful adoption will not occur until the total economic value proposition can be realized. This relates to the technology's effective price as well as its reliability. There is a sense among surveyed growers that though many tasks could be accomplished mechanically today (particularly by an autonomous technology), they cannot be done more cost effectively than with human labor. In terms of business models, purchase models (versus service models) have proved untenable when investing in new technologies, and non-passive tech (which requires high levels of interaction) have made even trialing new tools too costly.

Voices of the Industry

"Many of the companies that are presenting technology are on a shoestring and they're selling something that they think is very exciting. And it probably is, but they're not quite there yet. I think many of us have watched this process, where they've got all the answers, and then five years later they're backing out and saying, okay, we're bankrupt. And then the growers have also invested in the process, because of the potential. And so I think many participants are getting a little jaded and insisting that, okay, that looks exciting, but you don't have any track record. I can't really afford to pay you to figure this out."

–Washington Apple Grower

Technology Proliferation & Low Success Rates. Given the proliferation of technology, growers now need to identify all the tech that could have a positive impact in a given operation, have the resources to appropriately explore those options, and have the confidence necessary to invest in piloting or adopting that technology. Fatigue from these increased requirements, combined with cases where the technology failed and/or the company went out of business, represent a possible drag on future interest and adoption rates.

The need to redesign orchard infrastructure in preparation for automation. More planar, 'robot ready' orchard systems often require more management/labor in the nearterm, and are not equally accessible given the growth characteristics of trees/certain varieties. This might mean that there are savings related to picking, and the ability to yield more target fruit, but there's more infrastructure and tree management costs throughout the season. Therefore growers, when making short term investments, must optimize between short term yield and the ability to use autonomous equipment in the future.

A key aspect of this challenge is ensuring that new infrastructure is not only appropriate for automation, but also improves the efficiency of hand harvesting in the meantime. Most growers are open to adopting new trellis systems, but the goal would be for those systems to remain in place for 30-50 years, given the price tag.

Solving for total cost of ownership. Managing grower's existing fleets already involves significant outlay for parts, fuel, and mechanics, and is often a high risk endeavor when the annual productivity of a 10 acre block could be slash considerably by a fan that's offline for an hour in the middle of the night. As the industry looks to increase mechanization and automation, ensuring that there is attention paid to how these new tools will be serviced, repaired, and fueled can not be overlooked.

Perception of difficulty of certain tasks. Especially for tasks like thinning at early stages, there are certain activities that growers perceive as being more difficult to mechanize than handling mature fruits. This could mean that growers (and technologists) show less interest in these solutions and are less vocal about the need for them, which may lead to diminished investment in them over time.

Limited opportunities in new varieties. The apple industry is unique within fresh fruit in having established name-recognized varieties that correspond to higher value products. Over the past decade or two, this has presented an opportunity for growers to increase margins. Today, however, there is variety fatigue among growers, many of whom believe that we've reached "peak-apple-diversity" on the consumer level, and who therefore are uninterested or unwilling to adopt new, unproven varieties, especially if they are perceived to be more difficult to manage horticulturally.

Lack of awareness of the potential of non-obvious technologies. One grower pointed out that one of the technologies that most dramatically impacted the apple industry in the past was cold storage. However, interestingly, "I need to be able to sell apples year round" was not a likely focus for growers prior to cold storage, because it was a simple impossibility. There could be additional opportunities in this vein– unknown unknowns– that could revolutionize the apple industry not because it solves a key existing issue, but because it unlocks a completely unrealized opportunity.

Growing concern about the availability of a tech-literate workforce. As the apple industry looks to a more autonomous/mechanical future, growers worry about having the right people and skills to operate more complicated machines. This concern serves as yet another barrier to

purchasing robotic/autonomous equipment, as growers are unsure as to whether or not their employees will be able to maintain and repair their machines. More broadly, there is concern about a lack of entry level people to train up through apple business, casting uncertainty on who the managers and leaders of the apple sector might be in the future.

Further, the skill and education levels of the apple industry workforce can be a limiting factor in communication (e.g., between technology companies and end users; owners to workers; etc.), impacting requirements for user experience and even adoption more broadly.