PROPOSAL TITLE: ROBOTICS READY DATA STANDARD FOR WASHINGTON APPLES

Report Type: Final Project Report

Primary PI: Ryan Bolduan, CPO
Organization: Yamaha Agriculture Australia
Email: ryan.bolduan@yamaha.ag
Address: 422 Portage Ave
City/State/Zip: Palo Alto, CA 94306

Co-PI 2: Ines Hanrahan
Organization: Washington Tree Fruit Research Commission
Email: hanrahan@treefruitresearch.com

CO-PI 3: Nolan Paul, CEO
Organization: Yamaha Agriculture Group
Email: Nolan.paul@yamaha.ag
Address: 422 Portage Ave
City/State/Zip: Palo Alto, CA, USA

Co-PI 4: Steve Saunders, CEO
Organization: Robotics Plus Limited
Email: steve@roboticsplus.co.nz
Address: 37 Newnham Road
City/State/Zip: Tauranga 3172, New Zealand

Cooperators: Tory Schmidt, WTFRC

Project Duration: 1 Year

Total Project Request for Year 1 Funding: $75,000

WTFRC Collaborative Costs:

Item	2024
Salaries	$69,138
Benefits	
Wages	
Benefits	
Supplies	
Travel	$3,600
Total	$72,738

Footnotes:

Budget 1

Primary PI: Ryan Bolduan, CPO

Organization Name: Yamaha Agriculture Australia

Contract Administrator: Thashnie Angus, CFO

Telephone: +1 (831) 254-7190 (US mobile for Ryan Bolduan)

Contract administrator email address: thashnie.angus@yamaha.ag

Yamaha Agriculture Australia Costs:

Item	**2024**
Salaries	$69,138
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Travel	$3,600
Total	$72,738

Robotics-Ready Data Standards for Washington Apples

Final Report, November 2024

Yamaha Agriculture

Intro:

The Washington Tree Fruit Research Commission (WTFRC) has built out a technology roadmap, and part of that roadmap addresses how to effectively support and deploy robotic technology to improve efficiency, profitability and address key challenges facing Washington's apple industry. The technology sub-committee awarded a grant (Harvey_RoboticsReady) for 2024 with a goal of discovering the key technology vendors used by growers, and the kinds of data that they manage, as an input into longer term goals of developing data analytics and robotics ready guidelines for use by the Washington tree fruit industry.

The objective of this report is to document the findings from interviews with growers to better understand which technology vendors the industry is using and how they are managing their data. Additionally, this report includes both near- and longer-term suggestions for how stakeholders can work towards the development of robotic ready standards for Washington State apple producers.

Key Findings:

- **86%** of respondents are willing or very willing to adopt new software vendors if they can demonstrate improved operational efficiency.
- **76%** of growers are likely to implement a new robotics solution within the next 5 years, and the same percentage believe that automated data collection technology could help address pain points in the growing process.
- A significant number of respondents (**47%**) have already started trialing robotics solutions, with a concentration of these trials in the Yakima Valley.
- The majority of respondents (**81%**) report that collected data is only being used effectively *some of the time.*
- The top three challenges when using software for data collection and management include inability to connect with other applications, inconsistent data collection across sites, and difficulty in taking actionable steps from the data provided.
- A majority (**62%**) experience medium to high frustration with the inability to exchange data seamlessly between different applications and systems.
- **57%** of respondents cited budget and cost limitations as the primary barrier to adopting new technologies, while **52%** prioritize cost-effectiveness when selecting a software vendor.
- When evaluating robotics solutions, **71%** of respondents value ROI as the most important factor, followed by technical support (**48%**) and affordability for long-term deployment (**38%**).
- The top three benefits respondents expect from data standards were identified as: greater precision and new insights enabling better growing decisions and quality outcomes (**38%**), greater precision driving cost savings on labor (e.g., when/where to apply chemical thinner, collecting data) (**38%**), and greater automation driving savings on manual activity on the farm (**38%**).

Methods:
The research studies leveraged the interview method previously utilized successfully by WTFRC to develop their technology roadmap. Early feedback on the initial grant application suggested that the industry had "survey fatigue" and that past surveys had mistakenly focused on only "the big five" apple growers. A Grower Advisory Board was established to provide input into the design of and to participate in the research study. Research study participants were identified by the Washington Tree Fruit Research Commission to include organizations of different sizes and across different regions.

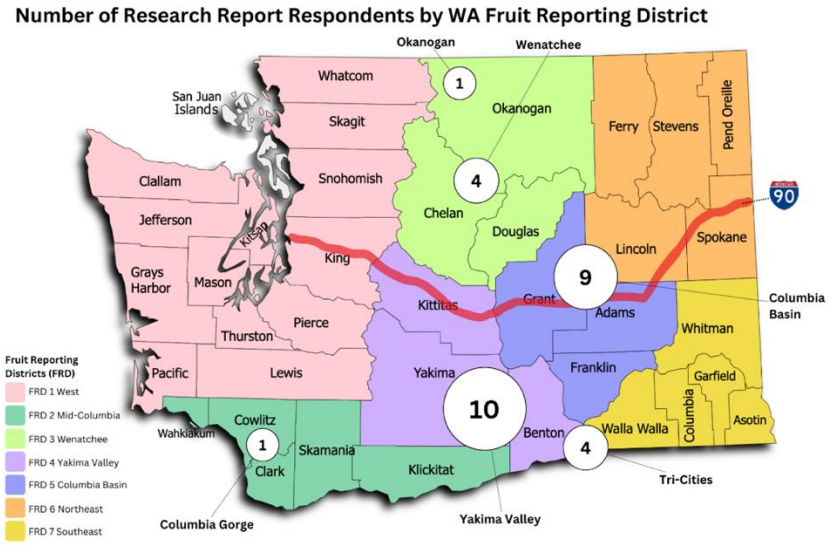

Figure 1: Number of respondents to research study

The research study participants were selected to represent a range of companies, business models, production regions and acres under management to reflect industry wide trends. Specifically with regard to size of acres under management, **28% of respondents operate farms with 5,000 or more acres and 14% operating farms with 1,000 acres or less**. All respondents grow apples and many also grow at least one other crop (**95% cherries**, **67% pears**, **33% wine grapes**).

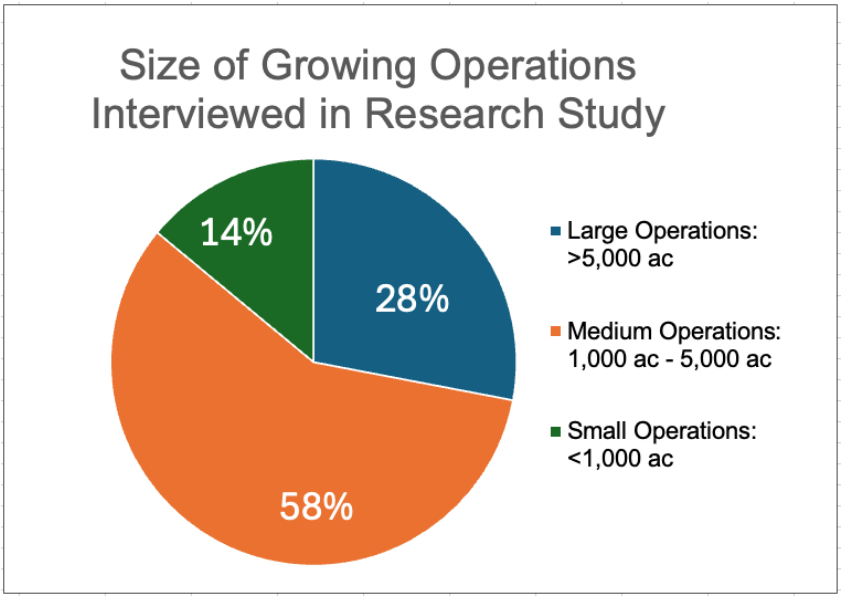

Figure 2: The research study intentionally included growers from a range of operational sizes.

The research study conducted 21 in depth interviews via video conference to facilitate the process and allow the gathering of both quantitative and qualitative data. Vendor lists were distributed in advance and organized in a manner similar to how The Mixing Bowl publishes their AgTech Landscape Roadmaps (link to Mixing Bowl AgTech Landscape 2019 here). Responses from interviews were documented by interviewee and company, and then anonymized for reporting to protect participants' privacy and company intellectual property (IP).

The term "interoperability" is a term that will be referenced throughout the report. Interoperability is a term that gained popularity in early 2000s and refers to the ability of computer systems or software to exchange and make use of information between systems, allowing users to share data across different apps to enable a user to make a decision more easily by presenting information from both systems in one spot. Interoperability is fundamental to being able to have the data from various apps come together in one place, be able to run analysis on the data, and ultimately for enabling robots to make recommendations or decisions autonomously.

Results and Discussion:

The Washington State Tree Fruit Research study indicates that the industry is positive about adopting new software and automation technology so long as it is easy to adopt; integrates into current systems; unlocks greater efficiency; and quickly returns benefit to operations. Growers were loud and clear that they want cost-effective solutions that work reliably, have a user-friendly interface and offer dependable support.

While there's increasing interest in incorporating new AgTech solution technologies, many growers are still struggling to fully implement widespread solutions at commercial scale. Many operations are still dependent on significant manual data collection, and while the manual data collection may get the job done today, it also means that potentially valuable data is not accessible to be included for future analysis. The top barriers to day-to-day implementation of software solutions are a lack of reliability and connectivity in more remote locations and low or delayed ROI (especially the length of the payback period). Some technology vendors have made significant progress addressing these challenges, so their adoption rates are on the rise. However, the data collected by these solutions are still often siloed, so the opportunity for improved interoperability remains.

Today's Ag Software and Automation Technology Landscape

Most growers shared their strong inclination that implementing software and robotics solutions over the next 5-10 years could transform agriculture as we know it. Furthermore, **86%** of respondents are willing or very willing to adopt new software vendors that demonstrate improved operational efficiency. Within the next 5 years, **76%** are likely to implement a new robotics solution, and the same percentage believe automated data collection technology could help address pain points in the growing process. A significant number of respondents (**47%)** have already started trialing robotics solutions, with most of those trials taking place in the Yakima Valley.

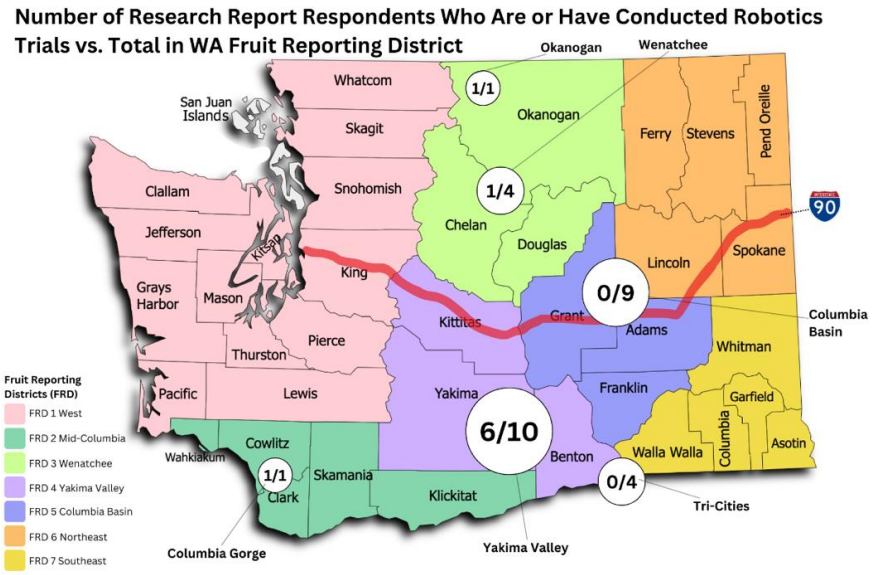

Figure 3: Robotics Trials Mentioned in Interviews

Despite the high level of interest in utilizing data as an input to their decision-making process, many growers rely on manual data collection for both on-and off-farm activities. More than half (**53%)** of respondents noted that they currently schedule activities, such as irrigation, mowing and scheduling of crews manually.

Even those who are using software vendors say they are still facing challenges. Most respondents expressed that the data they are currently collecting *is not being used effectively:* **81%** believe that they are only using the data they collect effectively *some of the time*, and they noted that interoperability must improve for more widespread technology adoption and to get the full benefit of the data that is being collected for analysis. Below are some key responses from growers selected during the interview process:

- The top three challenges that respondents face when using software vendors for data collection and/or management include the inability to connect with other applications that they have implemented on farm, inconsistent data collection (at one site or at different sites)**,** and difficulty in the ability to take action from the data that they are provided with.
- Budget and cost limitations were identified as a top barrier to new technology adoption by **57%** of respondents. Cost-effectiveness is also a top priority when selecting a software vendor, according to **52%** of respondents.
- Other barriers to new technology adoption include connectivity issues, which have restricted access to using apps in the field **(43%)**, lack of interoperability with other apps **(38%)** and lack of trust in predictions made by technology **(38%).**

Interoperability continues to be a significant roadblock growers face when implementing new technologies. A common example that growers expressed was frustration with needing multiple tabs open and juggling various solutions to manage software solutions and to consume data that they have collected through various apps or sensors on farm. When asked how frustrating it is that they can't easily exchange data between different applications and systems, **a majority (62%)** said they have medium to high levels of frustration.

These gaps between data collected and the ability to use the data present an important opportunity for technology vendors to help tree fruit growers and the agriculture industry more broadly become more efficient and increase profitability. Later in this report, we will discuss both short-term and longer-term actions that the industry can take to improve the interoperability of the data that they collect.

Current Vendor Landscape

The apple industry has for years been approached by vendors who hope to introduce technology into industry, with varying results. Some vendors have gained more traction than others, and an important part of the research study was to identify the technology that is currently deployed to help solve industry problems on and off the farm.

During the discussions with growers the primary considerations were to identify the market share of vendors within the apple industry alongside the total amount of acreage impacted by each vendor solution mentioned, and to conduct an analysis of the representation of different software technology categories.

For those already using technology vendors to manage on-and off-farm data, the top-mentioned companies were: **PickTrace (61%), Google Earth (47%), AgWorld (33%) and Orchard Robotics (28%).** Many of these solutions are tied to compliance-based areas such as payroll compliance and pesticide application whereas Orchard Robotics' early success differentiates itself and demonstrates industry excitement for on-farm visual metric data that can be acted upon.

Although some examples of collaboration between various AgTech companies were mentioned, such as Orchard Robotics collaborating with Advanced Farm this past season, most of the technology vendors are operating as self-contained solutions because no common standard for sharing data between these companies exists. A recent panel discussion at FIRA USA in Woodland, CA, moderated by WTFRC, highlighted the need for collaboration between vendors, since the data driven solutions that growers desire will require integration from various areas both on- and off-farm.

Robotics Seen as the Future, and Growers Are Eager to Implement

Growers expressed positivity about robotics solutions in a similar manner to software solutions — while advanced technology is desirable, it must be affordable and provide near-term ROI, especially given the current economic climate of tighter margins. Growers are eager to adopt robotics and automation that will streamline labor-intensive tasks and optimize processes once these solutions are proven to work in practice and to provide bottom-line benefits sooner.

- When evaluating robotics solutions, the top three factors respondents consider most important are ROI **(71%)**, technical support and maintenance services from the vendor **(48%),** and affordability and cost-effectiveness for long-term deployment **(38%)**.
- When asked what capabilities they would like a robotics solution to offer, the top three responses were: automated harvesting and sorting for increased efficiency **(76%)**, autonomous spraying and fertilizing for precision agriculture **(52%),** and crop load or yield forecasting to aid in planning and resource allocation **(29%)**.

It is also worth mentioning here that autonomous robots passing through the orchard have long held the promise of passive data collection that can be utilized for data analytics. Passive data collection by robotics, once it becomes technologically feasible and cost effective, can provide well organized data at large scale as inputs into analytical models.

- The top three most important areas of grower interest for on -arm visual metrics to collect were: yield prediction (57%), fruit count (48%) and flower count (43%). Fruit count and flower count key inputs for crop load management, which is a priority area of interest within the WTFRC roadmap.

Digital technologies like software and robotics *have already, or will in the next 5-10 years*, drastically change agriculture as we know it, according to **86%** of respondents. So, with robots, autonomous vehicles and advanced visual imaging technology on the way, where should parallel efforts begin now to be ready to fully benefit from the data and technology of the future? Industry wide data standards that support interoperability will go a long way to getting full benefit from data collected now and in the future.

The Case for Data Standards

There is a growing use case to be made for industry-wide data standards in AgTech, particularly as precision farming and robotics play a more prominent on-farm role. As one grower said, "If we could all be using the same sort of data, and we come to the same conclusions and can articulate what we are experiencing then maybe we would have a better outcome when trying to tell our story." Another grower added when asked if he is using the data he collects effectively, "You are only as good as the data you collect," and collecting good data requires a plan and architecture for how that data will be used downstream.

It is worth mentioning a bit of history of standards to provide context for how agricultural standards can be approached today, since successful development of standards will need to be built upon previous standards. The International Organization for Standards (ISO) started in 1946 after WWII to standardize measurements such as temperature and length. ISO now claims 25,617 standards deployed across various technology, management and manufacturing use cases in over 172 countries.

The reference to ISO is important, as developing standards for emerging markets and new applications build on top of existing standards. Investing the significant time required to understand current standards will be important for proactive standards development in the field of precision agriculture.

ISOBUS (ISO 11783) is a standardized communication protocol used since 2001 in agricultural and forest machinery, with a goal of enabling "plug and play" interaction between vehicles (e.g., tractors) and implements (e.g., sprayers). "Plug and play" efforts set out to provide seamless integration to avoid cluttering tractor cabins with implement-specific terminals and instead control any implement from a single, universal terminal – a use case that has parallels to a desired state that was shared by numerous respondents from the research study where data from various on farm apps can come together for analytics and visualization in one place.

We can see an example of how this standard has enabled cross vendor technology with real grower benefits in the work done by the Agricultural Industry Electronics Foundation (AEF), which originated when 7 large equipment manufacturers voluntarily came together to define common use cases and dedicate technical resources towards novel application of broader existing standards. Utilizing the ISOBUS standard, this organization has developed Tractor Implement Management (TIM), launched in 2019, which is a cross vendor agricultural technology where the implement can bidirectionally control certain tractor functions. For example, where the forward speed of a tractor can be controlled by a smart implement to optimize the job that the implement is designed to perform (e.g., weeding or variable rate applications).

To reiterate, existing standards play an important role in our day to day. Decades of standard development have been set as a foundation, but significant work is required to develop standards for precision agriculture that meet the needs of the apple industry. For standards that are not driven by mandatory risk mitigations, proactive engagement by industry is important to make progress. Trade associations such as WTFRC play an important role in advancing this work on behalf of industry.

Growers: What Growers Can Do

Firstly, growers need to identify the key problems that they want to solve or benefits that they want to achieve. Additionally, they can proactively manage the data that they control and enforce a degree of standardization within their own organizations.

Earlier in the report it was mentioned that only **29%** of respondents emphasized the importance of owning their data when using third-party software. While it is understood that growers generally want the technology to "just work" and leave the interoperability work to vendors, growers have an important role to manage their vendors to ensure that the data that they are paying for will meet their longer-term goals. Additionally, it is important to remember that vendors have other customers in different industries, so it is important to advocate for apple specific needs where they arise. There are resources available to provide guidelines on data ownership, data usage (e.g., by third parties, etc. see https://www.agdatatransparent.com/principles for further examples) and providing data dictionaries and APIs (application programming interfaces) to facilitate seamless interaction with other applications.

The top three benefits respondents expect from data standards were identified as: greater precision and new insights enabling better growing decisions and quality outcomes **(38%),** greater precision driving cost savings on labor (e.g., when/where to apply chemical thinner, collecting data) **(38%)**, and greater automation driving savings on manual activity on the farm **(38%)**. Additionally, effective crop load management was the number one choice from respondents when asked where they think they will get the most ROI from industry data standards.

Once the end-goal is clear, the next step is to identify what data is needed to achieve that goal and conduct a systems audit to understand where that data is currently held, what's the source of truth and where it's used. The data required may be held in a variety of diverse systems. For example, orchard management, agronomy software, labor management software, ERP and packing house software that manages fruit yield and quality information may all have pieces of the data needed to inform key data driven decisions. Accessing and deploying that data in support of data driven decision making can be facilitated by developing internal standards on where to store data and naming conventions.

Once the relevant data has been identified, the next step is to assess if the data complies with the following principles (The purpose of including these in this report is to provide practical improvements that can be done within an organization and are not dependent upon waiting for advances in robotics down the line.):

- Uses common identifiers across disparate systems to identify various locations and crops (e.g., block and row identifiers, variety identifiers, etc.) so that you can join data across systems.
- Distinguishes between blocks (the place) and plantings (what's grown in that place). This allows systems to identify where a new variety has been planted in the same block while maintaining the block level association for both plantings. The ability to manage blocks and plantings separately sounds simple, yet in many cases require changes in how the data architecture for the system of record differentiates the different data inputs.

- Being able to link what has been picked to what has been packed. Ultimately, as systems can identify activities at the sub-block level, it will be important to be able to identify what row or percentage of the block was affected.
- Ensuring that you do not overwrite data as it changes over time and collect and store additional information to ensure that data can be interpreted unambiguously (e.g. includes time zones with timestamps, units with any measurement values e.g. tons, miles, etc.).
- Maintaining a history of block names and identifiers marking when they were changed and where they were used can establish this across systems and across time.
- Having consistency in terminology, ensuring key pieces of information have standardized values (e.g., “Cosmics” vs. “Cosmic Crisp” vs. COSMIC Crisp”), ideally across the industry.

In addition to investing time into standardizing internal data, it is equally important to prepare the workforce. Some employees will see automation and analytics as a threat, scared that new technology will take their jobs. Educational programs that mirror the extension efforts that accompany new varieties, and other new tools will be important to implement. Extension efforts have proven to be a successful way to help people understand how to adapt to changes on farm and within operations and provide examples for how people can benefit from using new technology. Socialization is important for any change, and getting the buy in from the workforce is an important factor in implementing new ideas successfully, especially one that may be viewed as competition to an employee’s responsibilities.

Conclusion:
Growers are optimistic about the potential of technology, provided it enhances their operations and delivers tangible benefits. However, a collaboration on standards across technology vendors in the industry will ultimately be required to achieve the solutions that growers are interested in implementing long term. Many tree fruit companies are willing to try new things but lack the budget for unproven solutions or tools that only offer one specialized area of support.

The demand for data standards is evident, presenting a significant opportunity for greater data mobility across the agriculture industry to speed up benefits to the entire supply chain. Software, and robotics vendors, along with industry and regulators, can help address current challenges by establishing common data frameworks to make their solutions less siloed, more interoperable, and easier to adopt incrementally. A focus on near-term ROI will also help fund long-term technology investments, driving efficiency, effective agricultural practices and increased profitability for tree fruit companies. Longer term, the development of standards through collaboratively bringing together software vendors, robotics vendors, broad industry representation and regulators can continue to be spearheaded by trade associations such as WTFRC. Industry trade groups, such as WTFRC have been shown to play an important role in similar successful efforts. Providing input to existing standardization efforts to ensure that tree fruit needs are addressed will require a proactive approach. Growers and vendors can also align their work towards standardization, in the short term by establishing common data frameworks to make their solutions less siloed, more interoperable, and easier to adopt incrementally, and longer term by proactively participating in industry level conversations.

Technology adoption is clearly of interest to growers — it’s just a matter of when the technology can adapt to meet growers’ needs for efficiency and ROI. As one grower stated in their interview, “I think there is room for improvement in the industry. We must stay wholeheartedly in this and embrace technology for increased efficiencies to make this a better future for the youth who are coming in behind us."

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Executive Summary

Project title: Robotics Ready Data Standards for Washington Apples
Key words: “Robotics ready”; “automation”; “robotics”; “data standards”

Abstract:
A 2024 study by Yamaha Agriculture and the Washington Tree Fruit Research Commission (WTFRC) reveals Washington apple growers are ready to modernize their operations through robotics and technology adoption. It provides insights into current technology integration, data management, and automation methods in apple orchards and other tree fruit crop operations.

Research study participants were selected to represent a range of companies, business models, production regions and acres under management to reflect industry-wide trends. Specifically with regards to size of acres under management, 28% of respondents operate farms with 5,000 or more acres, 58% operate farms between 1,000 - 5,000 acres, and 14% operate farms with 1,000 acres or less. All respondents grow apples and many also grow at least one other crop (95% cherries, 67% pears, 33% wine grapes).

An overwhelming 86% of growers believe digital technologies are poised to reshape farming within the next 5-10 years, and nearly half of growers (47%) have already begun testing robotics solutions, with most of those trials taking place in the Yakima Valley. In the current technology adoption landscape, leading software solutions include:

- PickTrace (61%)
- Google Earth (47%)
- AgWorld (33%)
- Orchard Robotics (28%)

Growers believe that automation could support many functions of their operations, including harvesting and sorting (76%), autonomous spraying and fertilizing (52%) and both crop load and yield forecasting (29%). However, many express frustrations with the current state of technology integration – 62% of growers reported they currently struggle with systems that won't communicate with each other. The top concerns with implementation of robotics solutions include cost and ROI (57%), rural connectivity issues (43%), and limited interoperability between systems (38%).

The study underscores the case for industry-wide data standards to enable seamless integration of emerging technologies. Growers stated their optimism about the potential of technology, provided it enhances their operations and delivers tangible benefits. However, a proactive collaboration on standards across technology vendors in the industry will ultimately be required to achieve the solutions that growers are interested in implementing long term.