WTFRC Technology Roadmap

Short-list Priority: Irrigation

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Current Irrigation Technology Landscape

The irrigation technology landscape can be broken down into three, heavily-interconnected categories; hardware, optimization software, and control systems. Advanced irrigation hardware is the most widely adopted of the three categories, with adoption rates of associated software following closely behind. Advanced irrigation control systems are becoming more common, but are still not widely adopted.

Voices of the Industry
"It's cool to see some of these new, control technologies being adopted. Being able to run things on your phone from anywhere, and set programs and be able to fine tune your water usage." –Washington Apple Grower

Irrigation Technology Categories

Irrigation Sensors & Infrastructure: Hardware advances in orchard irrigation continue to help growers reduce costs related to pumping as well as preserve water resources and optimize tree health. Some of these advancements have been made at the irrigation system-level, leading to more optimized systems (e.g., sprinklers, drip, subsurface drip, fertigation, etc.). Other advancements have been made with regards to supplementary tools like soil moisture sensors and alternative energy-powered pumps.

Example offerings include:

- Netafim: drip and micro-irrigation solutions
- Toro: smart controllers and precision sprinklers
- Tule by CropX: in-field sensors
- Dynamax: soil moisture, stem flow gage, and other in-field sensors
- Nelson: Twig-V Wireless Automation System

Irrigation hardware is a category that encompasses everything from pipes and pumps (the essentials of any irrigation system) to state-of-the-art soil probes and automated valves. Given the breadth in this category, every Washington apple grower with irrigation has embraced irrigation hardware tech of some kind. Though there is no specific data available on how widely adopted newer irrigation hardware tools are among Washington apple growers, anecdotally, producers are generally familiar with soil moisture sensors, tree- and fruit-mounted sensors, advanced pumps and nozzles, and pressure monitors. Many are already using these technologies, either via trials or full adoption across part or all of their operation. A more tangential aspect of newer irrigation technology promises to marry the latest in soil mapping with irrigation to enable variations in water application rates across the orchard. However given the current state of technology, to do this would require massive capital investments to redesign irrigation system infrastructure. This is being pursued in other regions where water shortages create additional incentives, but is unlikely to be justified in the near term in Washington orchards.

Generally, since soil moisture sensors have been around in one form or another for nearly a century, there is more conviction that the information they supply is actionable, versus other,

newer sensor types. Notably however, soil moisture sensors must also be calibrated to be accurate, an activity which is not always performed.

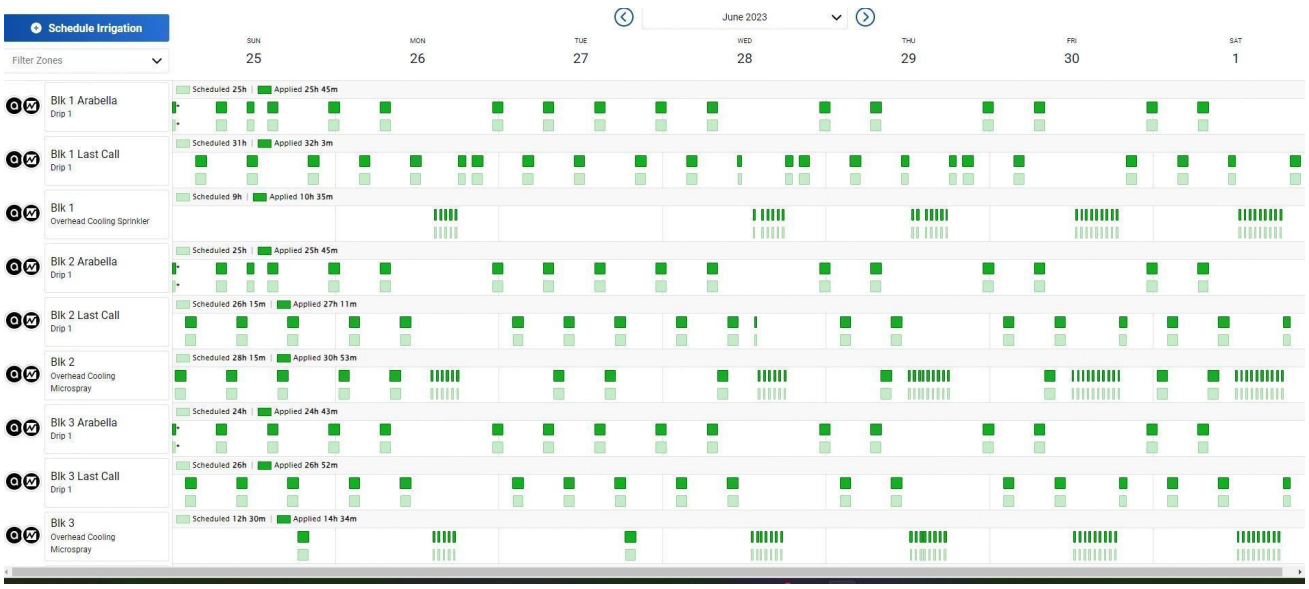
Irrigation Optimization Software: Irrigation software systems allow for the integration of GPS data, aerial and satellite imagery, and other data about crop health and soil moisture levels into the irrigation decision-making process, offering opportunities for growers to use water resources more efficiently. Many of these systems require cloud-based analysis, due to the high quantity of data involved. Data from soil, tree, and fruit sensors can provide real-time information about water needs, allowing growers to make informed decisions about leaving irrigation systems off longer to conserve limited water allocations and/or to fine-tune deficit irrigation schedules to minimize water usage without causing extensive yield damage and/or to optimize fruit quality (i.e. bitter pit management) and fruit size.

Beyond orchard performance optimization, these irrigation tools also collect and record water-use data that could be useful in the future for marketing purposes (e.g., "water smart" apples), for regulatory compliance, and/or to respond to investor demands for the sustainability credentials of orchard operations.

Though many apple growers in Washington do not struggle with water shortages, junior water rights holders and those located in more marginally geographies are sensitive to the volume of water used. Given that many Washington apple growers are not water-limited, over-irrigation is much more common than under-irrigation. Over-irrigation, though it has few direct negative impacts on tree health, can affect a growers ability to run equipment in orchards, can waterlog roots and impact plant health, and most critically, can increase costs through nitrogen leaching, which increases the need for supplemental fertilization over time. By narrowing in on optimum irrigation (and exploring irrigation strategies that allow for more water infiltration into the root zone alone, which tend to be more frequent and for shorter durations), some growers are maintaining more soil nutrients throughout and between seasons, over time leading to less need for supplemental fertilization.

Example offerings include:

- SWAN Systems: Irrigation optimization software (AU)
- Wilber-Ellis Probe Schedule: Irrigation scheduling software
- Semios: Irrigation planning and monitoring software plus data analysis



Screen Capture of a typical irrigation schedule, Courtesy of Semios

Though many irrigation hardware tools that deliver data come with associated software, it is unclear how commonly adopted the softwares/apps are amongst Washington apple growers. Though many growers have access to them, whether they regularly consult the software, or when they do, there is uncertainty about whether they or their irrigators are able to translate that information directly into effective irrigation planning. It is likely that fewer growers are utilizing irrigation software than irrigation hardware, and that the most commonly used features are relatively basic soil moisture models and evapotranspiration data reports.

Advanced Irrigation Control Systems: Irrigation control devices and/or platforms integrate both software and hardware, as well as combine historical weather data, soil moisture sensors, and other inputs like forecasts to optimize irrigation scheduling and in some cases even automate irrigation to manage flows in real-time. Many tools in this category allow for remote monitoring and control via mobile apps or online platforms.

Labor savings is a major value proposition of these systems, especially because, too often, irrigators spend much of their time carrying out rote, laborious tasks like turning valves and manually checking pressure gauges. Though advanced irrigation tools do not eliminate the need for irrigators in the orchard, they can transform the tasks of irrigation from ones focused on doing (e.g., turning values) to monitoring (e.g., verifying that the valve is open, checking irrigation lines, etc). Not only can this reduce the time it takes to manage the irrigation process– freeing up the irrigator to support other tasks in the meantime- it can also allow for improvement in the overall process.

One such improvement is that control systems allow growers to experiment with alternative irrigation strategies like pulse irrigation, which is a process by which trees are irrigated multiple times per day for extremely short durations. This strategy has anecdotally resulted in yield gains in other tree crops,[1] but the main barrier to carrying out pulse irrigation in apple orchards is the amount of labor required to manually operate valves. Systems that allow valves to be turned automatically can allow for experimentation with irrigation plans that might be beneficial in terms of yield and quality, without dramatically raising irrigator-related labor costs.

Example offerings include:

- Phytech: direct plant sensing and data analytics to inform optimized irrigation
- Wiseconn: wireless hardware installed in the field and software for monitoring, control, and automation

Control and monitoring solutions are the most recently commercialized irrigation tools. Anecdotally, these systems are currently not widely adopted, though there is increasing interest, especially among large growers. The introductory value proposition usually revolves around monitoring– allowing growers to verify that their irrigation plan is being carried out by their employees. Technology vendors often focus on this initial, and less complex, value proposition because of a persistent lack of confidence amongst growers in the remote control aspects of the systems. While full automation of irrigation promises labor savings, the reality is that growers still desire significant oversight of their systems to manage the risk of possible losses, and so the touted benefits are not realized. In other words, though completely automated scheduling and execution may be possible, there are significant - albeit justified - psychological barriers (i.e., loss aversion) to adoption.

[1] Extensive discussion in Wiseconn interview transcript. Also see Wiseconn case studies with tree growers who have seen significant success with pulse irrigation here and here.

Barriers to Adoption of Irrigation Tech in Washington Orchards

Overall Opportunity for Growers: The key opportunities of adopting irrigation technologies are:

1) cost savings, particularly in terms of water, energy, labor, and nutrients;

2) increased confidence in irrigation decision-making; and

3) the ability to explore new irrigation strategies that could have direct benefits to yield and quality.

Further, there's also emerging evidence that adoption of irrigation technologies could also unlock additional revenue streams, for example via ecosystem service payments.

However, for most growers to seize these opportunities, several barriers will have to be overcome.

Support: The question of who will provide hardware maintenance and help trouble-shoot software, especially during particularly sensitive times of the year, remains relatively unanswered in the irrigated orchard space. In general, irrigation supply and installation companies do not install emerging irrigation tech tools (i.e., sensors, software, automatic valves, etc.), and thus do not service them. Growers must therefore rely on irrigation technology companies themselves for maintenance and support, but these companies often lack the resources to employ sufficient field service support. Larger growers may have on-staff tech support that can calibrate sensors and debug software, but medium and small growers are more dependent on limited regional support staff to deal with issues as they arise.

Cost: Especially for small/mid-sized growers, cost of technology remains a concern. Though there is a consensus amongst irrigation experts that per-acre returns to investments in irrigation tech tend to be consistent across scale (i.e., such that bigger growers do not benefit more than smaller ones), larger growers are better able to amortize costs across a larger footprint.

Learning curve to effective use: Though irrigation software systems are becoming increasingly intuitive to navigate, translating the data from various sensors into decisions and then actions requires both education and habit-building. This work is unique to each operation and requires both training and incentives that prompt growers and irrigation managers to change practices (e.g., regular interaction with the tools). Summiting this learning curve is inevitably more difficult for more resource-constrained, or less technology-savvy, growers.

There are multiple layers to this barrier throughout the orchard and across roles. Irrigators who use the tools daily to control irrigation have to learn how to use apps to follow a predetermined schedule. Farmers/managers who create the schedule have to learn to read and analyze the data from multiple sensors and monitoring tools to determine an effective strategy. And at some level, owners/executives have to learn to create reports and read out data that's valuable to investors/regulators/etc.

Confidence in the system: Growers have varying degrees of confidence in different aspects of advanced irrigation technologies. While confidence in soil sensor data outputs is relatively high (perhaps too high given that many may be un-calibrated), grower confidence in monitoring systems is more spotty, and levels of confidence in control systems can be significantly lower still. Given the large amounts of capital involved, growers often do not perceive the benefits to outweigh the costs of a possible system failure.

Value proposition: Though there are cost-savings to be had from optimizing irrigation, it is not always clear to growers whether those savings justify the cost of implementing advanced irrigation systems. Lack of available, third-party verified data to that effect is a significant part of the problem.

Supplementary value propositions also tend to appeal to some kinds of growers more than others. For example, many software and monitoring providers point to the value of having access to data and reports around water-usage and climate impact. Though this is valuable for large, vertically integrated growers that engage outside investors especially, for many smaller, private growers who don't feel pressure to provide this information, this value proposition does not land.

Crowded landscape: Especially for the most commonly available tools like soil sensors, it is increasingly time-consuming and confusing to evaluate and select options. This is especially true for growers with fewer resources and/or capabilities. This is less of a problem when it comes to the control and monitoring technologies, of which there are fewer.

Irrigation Technology Strategies

A rapid increase in experimentation with, and adoption of, irrigation technology is possible in the next two years, though expectations should be tempered by the fact that a dramatic increase in the number of orchard acres utilizing these systems may not be possible in such a short window. Existing vendors recommend a multi-year adoption plan for growers, one which begins with step-wise exploration into sensors. These sensors can provide data for basic analyses, and then be combined with control and monitoring systems over time as growers gain confidence and competence with systems.

The following strategies have been identified to catalyze an increase in adoption:

Create and improve incentives for new and existing irrigation service providers to support advanced irrigation technologies. A major barrier to adopting more irrigation tech is uncertainty related to the cost and availability of maintenance resources. WTFRC can participate in encouraging organizations with existing service presence in the region to explore providing these services, as well as create incentives for new providers to fill the gaps.

End Goal: Eliminate real and perceived service gaps that can limit growers from investing in advanced irrigation technologies.

Priority: 2

Example Activities:

- Host or support events bringing together existing irrigation providers and other retailers/trusted advisors with irrigation tech companies to facilitate partnerships
- Encourage research into the benefits of supporting irrigation tech companies, irrigation companies, and/or growers to actually provide this support in such a way that enables them to move towards financially sustainable and adequate services
- Support total cost of ownership studies which directly quantify service costs/service opportunity for would-be providers

Increase the availability of third-party data showing the effectiveness of irrigation technologies. Most data about the efficacy of irrigation technologies in Washington orchards comes exclusively from the companies who deliver the tools. WTFRC can participate in funding activities that verify claims in real world operating conditions in the region, providing growers with additional resources to help them navigate the landscape of technologies.

End Goal: Increase confidence in the effectiveness of existing and emerging irrigation technologies.

Priority: 2

Example Activities:

- Support independent validation of irrigation company claims (for example, a trial around converting tree sensor data to real-time water demand)
- Fund commercial trials specifically tailored to the operating conditions of Washington orchards (e.g., comparison of tools to enable deficit irrigation)
- Publish findings of existing third-party data on effective use of irrigation technologies in accessible forms (e.g., videos, blog articles, etc.) & disseminate to industry
- Fund ROI analyses for existing technologies

Develop a local evidence base for how irrigation technologies can enable the use of non-traditional irrigation techniques that improve fruit yield and/or quality. In other geographies, and outside of apples, strides have been made related to unconventional irrigation techniques (e.g., pulse irrigation) facilitated by advanced monitoring and control tools. Washington's general lack of water constraints has resulted in more limited local experimentation, meaning significant yield/quality improvements may still be possible.

End Goal: Improve apple yield and quality through innovative irrigation techniques.

Priority: 1

Example Activities:

- Fund research trials applying the latest irrigation techniques (e.g., pulse irrigation, deficit irrigation, soil-type specific irrigation, etc.) in Washington orchards with a specific focus on results related to quality
- Support applied research projects with highly specific objectives, for example, studies around reducing the frequency of bitter pit in HoneyCrisp apples with deficit irrigation strategies (with a particular focus on how growers can pursue these practices)
- Curate and amplify existing research and case studies on trial and experimentation results from other regions
- Coordinate and encourage collaborations that integrate expertise from local irrigation districts

Document and share irrigation technology strategies that growers are using to reduce costs. Though irrigation tech can create both labor and input savings, the general lack of concrete information about these benefits means there's little confidence in these additional value propositions. Finding ways to circulate both qualitative and quantitative information about experiences in cost-savings will help WTFRC build grower member's trust in irrigation advances.

End Goal: Motivate adoption of irrigation tech by appealing to cost-saving opportunities, and leveraging social proof.

Priority: 3

Example Activities:

- Highlight available state and federal grants, tax credits, etc. that are available for growers that can prove reduced water usage; include case studies of successful applicants and the outcomes they achieved.
- Provide a clear informational link between the long-term impacts of over-irrigation and nitrogen leaching accessible (e.g., amplifying real-world data and case studies related to the long-term impacts via podcasts, videos, etc.)
- Support trials/pilots around the provision of ecosystem service payments
- Develop a publicly accessible 'logic map' to enable varied types of growers to understand their options for irrigation tech given their specific needs (e.g., acreage, budget, trellising type, existing irrigation systems, water rights, etc) and goals.

Build capacity and capabilities for the effective use of irrigation technologies. WTFRC can find creative ways to help growers summit the learning curve to both unlock investment in irrigation tech, as well as improve utilization of existing investments.

End Goal: Improve the confidence and skills of operators across all levels of orchard operations related to effective use and optimal utilization of irrigation technologies.

Priority: 2

Example Activities:

- Ensure existing field days/demonstration days include specific content aimed at training/education for irrigators (facilitated in Spanish)
- Create an online, at-your-own-pace "Irrigator University" course for growers and managers that is customized for WA conditions and provides support and instruction in data analysis and decision-making
- Partner with WSTFA to create training material
- Incentivize establishing farm-level and industry-level baseline for water usage levels, and potentially also power usage related to irrigation