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LAND-GRANT UNIVERSITY RESEARCH

# Automation for Specialty Crops

Specialty crops include fruits, vegetables, tree nuts, and nursery plants. Recently, the U.S. specialty crop industry has been faced with rising global competition, labor shortages, demand for higher quality, and concern about environmental impacts and sustainability. Automated devices can help with growing, harvesting, and processing if they are designed and implemented appropriately.

**Researchers at land-grant universities are working together—and with Extension professionals and industry partners—to develop automated systems that help optimize specialty crop production.**

Multistate, multidisciplinary coordination allows project members to share expertise and resources, making research and development more cost-efficient than if it were done by a single state or institution. Over the last five years, this project has made major advances in:

- Identifying key parameters for specialty crop production and developing sensors to measure them.
- Developing specialty crop production systems that are more amenable to mechanization.
- Designing automated systems and working with manufacturers and farmers to commercialize and implement them.

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## Research Highlights

### Improving sensors and imaging

Reliable sensing, imaging, and other data help estimate and map crop yield, quality, and other parameters so growers can manage inputs, negotiate pricing contracts, allocate quantities for sale, and conduct harvests efficiently. Project members have developed:

- Remote sensing technology to precisely identify vineyard areas that need more nitrogen, helping growers avoid over-application, which can harm vines, pose environmental risks, and be costly for farmers (University of California, Davis).
- Low-cost soil and plant moisture sensors that are easier to use and more accurate than traditional tools and facilitate irrigation scheduling (University of California, Davis).
- A lighting system that improves outdoor imaging by reducing color inconsistencies and decreasing motion blur (Pennsylvania State University).
- Fruit detectors that are more accurate in field conditions (Mississippi State University).
- An on-tree apple fruit sizing system with high-resolution cameras and artificial lighting that performs better than manual inspection (Pennsylvania State University).
- A sensing kit that enables earlier, more accurate yield estimates for grapes and almonds (University of California, Davis).
- Machine vision and deep learning to detect strawberry bruises and size in packinghouses (University of Florida).
- Advanced tomography, hardware, and computing that enable accurate evaluations of the internal quality of crops with hard shells/coverings. This system would allow grading and sorting of these crops without causing damage (Michigan State University).
- A smaller robotic cotton end-effector to replace mass cotton harvesting machines, which can cause problems in the fields, including soil compaction and pollution (Mississippi State University).

### Preventing strain and injuries

Newly developed automated technologies are being used to prevent strain and injury. For example:

- A new operator-assist apple harvest system eliminated the need for ladders and prevented ladder-related injuries, which occur about 200 times each year on average (Washington State University).
- Smart machines were used to inspect every truckload of processing tomatoes in California in 2021, so workers did not have to repeatedly lift and invert heavy containers (University of California, Davis).

*A mechanized device designed by Washington State University scientists helps automate apple harvest. Photo from Washington State University.*

### Reducing labor needs and costs

The specialty crop industry often relies on manual labor for a variety of tasks, but labor can be costly and difficult to secure during shortages. To overcome these challenges, project members developed:

- A 12-armed robot with machine vision that is 100% accurate at detecting apples in canopies and about 70% successful at picking (Washington State University with FFRobotics Inc.).
- A targeted shake-and-catch system for harvesting apples. This system has a much higher throughput than a robotic picking system and can achieve a 90% fruit picking rate while keeping fruit damage at about 10%. This design won the 2019 Rainbird Engineering Concept of the Year Award from the American Society of Agricultural and Biological Engineers (Washington State University).
- A computer-controlled orchard platform that can increase harvesting throughput by 26% (University of California, Davis).
- Simple, energy-efficient automated harvest tools that could be implemented by chestnut growers who can't afford mechanical harvesters but are too large to harvest manually. So far various prototypes have achieved about 80% harvest pick up efficiency (Michigan State University).
- Automated, robotic weeding systems to replace hand weeding and minimize chemical herbicide use (University of California, University of Kentucky, Michigan State University, University of Arizona).
- An automated grape thinning system that can be integrated with an existing commercial shoot thinning machine (Washington State University with VineTech).
- Financial benchmarks that help vineyard owners determine whether to purchase equipment or hire workers for specific vineyard tasks (Oregon State University).

## Managing pests and diseases

To detect pests and diseases more accurately and quickly than the human eye and apply treatments more precisely, researchers developed automated tools, including:

- An energy-efficient mechanized steam applicator that reduced fusarium wilt and lettuce drop incidence by over 70%, improved weed control by over 85%, and reduced hand weeding labor needs by about 30% while increasing yield by 24% (University of Arizona).
- An intelligent chemical sprayer system for fruit trees that reduced chemical use by 50% (Pennsylvania State University).
- A system that uses fixed lines and micro-emitters to deliver chemical solutions more precisely. In tests, aerial drift losses were as much as 99 times higher for conventional airblast sprayers than the new fixed spray system (Washington State University).
- A portable system that uses sensors, color imaging, and deep learning to detect strawberry plant wetness and optimize fungicide applications (University of Florida).
- Deep learning models that can be integrated into nursery/ greenhouse devices so they automatically scan crops and provide instantaneous reports on disease issues (Texas AgriLife Research).
- An autonomous robot that delivers UV-C treatments to vineyards to suppress powdery mildew (Cornell University with Saga Robotics).

## Reducing environmental stress

Researchers developed automated systems that can prevent crop damage from harmful environmental conditions, such as:

- Machines and cyber physical systems that perform frost protection tasks in orchards (Pennsylvania State University, Washington State University).
- Localized weather and fruit surface temperature sensing based precision and automated heat stress mitigation in apple orchards (Washington State University)
- A system that helps estimate and maintain the moisture content of green coffee through its distribution chain, which is key to coffee quality and price (University of California, Davis).

## Facilitating crop breeding

New automated X-ray imaging tools help screen peanuts for resistance to smut much faster than traditional methods, accelerating the development of resistant varieties (Oklahoma State University).

The RootRobot, which efficiently phenotypes corn roots and has helped identify corn varieties that need less space and fewer inputs to grow because they obtain nutrients and moisture from deeper in the soil (Pennsylvania State University).

## Facilitating adoption

To facilitate adoption of automated systems, project members led workshops and other events for specialty crop farmers, farmworker organizations, industry representatives, crop insurance companies, policymakers, investors, and others. After attending a University of Arizona workshop on automated thinning and weeding systems, several growers and companies adopted the technologies, saving an estimated 114,000 hours of labor and $1.4 million each year, and one manufacturer plans to redesign their equipment based on the knowledge gained.

*Project members at Pennsylvania State University developed drone-based systems to help specialty crop growers efficiently capture high-resolution crop data. University of Connecticut researchers outfitted drones with spectral sensors to reduce labor needs and improve the accuracy of detecting potato leafhopper damage on green beans. Studies at the University of Tennessee showed that drones could help pollinate crops without relying on declining wild pollinator populations or expensive commercial honey bee colonies. Photo from UCANR.*

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