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U.S. DEPARTMENT OF AGRICULTURE

Research-Driven Solutions for Improved Temperate Fruit Production and Profitability

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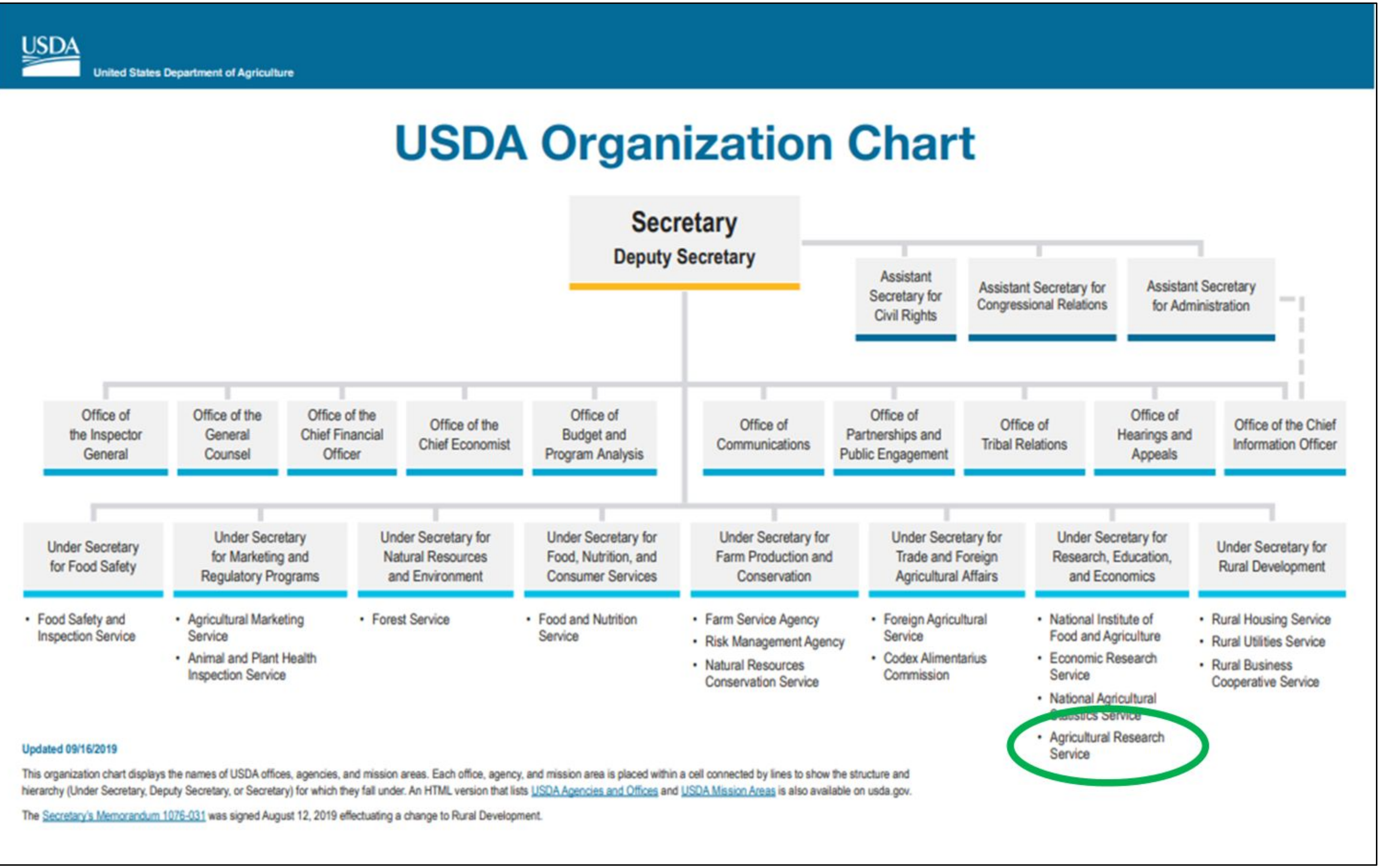
USDA
United States Department of Agriculture
USDA Organization Chart
Secretary
Deputy Secretary
Assistant Secretary for Civil Rights
Assistant Secretary for Congressional Relations
Assistant Secretary for Administration
Office of the Inspector General
Office of the General Counsel
Office of the Chief Financial Officer
Office of the Chief Economist
Office of Budget and Program Analysis
Office of Communications
Office of Partnerships and Public Engagement
Office of Tribal Relations
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Office of the Chief Information Officer
Under Secretary for Food Safety
• Food Safety and Inspection Service
Under Secretary for Marketing and Regulatory Programs
• Agricultural Marketing Service
• Animal and Plant Health Inspection Service
Under Secretary for Natural Resources and Environment
• Forest Service
Under Secretary for Food, Nutrition, and Consumer Services
• Food and Nutrition Service
Under Secretary for Farm Production and Conservation
• Farm Service Agency
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• National Institute of Food and Agriculture
• Economic Research Service
• National Agricultural Statistics Service
• Agricultural Research Service
Under Secretary for Rural Development
• Rural Housing Service
• Rural Utilities Service
• Rural Business Cooperative Service
Updated 09/16/2019
This organization chart displays the names of USDA offices, agencies, and mission areas. Each office, agency, and mission area is placed within a cell connected by lines to show the structure and hierarchy (Under Secretary, Deputy Secretary, or Secretary) for which they fall under. An HTML version that lists USDA Agencies and Offices and USDA Mission Areas is also available on usda.gov.
The Secretary's Memorandum 1076-031 was signed August 12, 2019 effectuating a change to Rural Development.


Northeast Area
ME
VT
NY
NH
MA
CT
RI
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NJ
DE
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NAL
WV
VA
MD
NC
USDA & ARS HQ

OUR USDA-ARS MISSION

ARS Mission

ARS delivers scientific solutions to national and global agricultural challenges

ARS Vision

Global leadership in agricultural discoveries through scientific excellence

Research Projects and Teams

Superior Fruit Tree Cultivars For Orchard Resilience, Sustainability, and Consumer Appeal

- Chris Dardick (Lead Scientist) - Plant Molecular Biologist
- Plant Molecular Biologist –Zongrang Liu
- Geneticist and Breeder – Chris Gottschalk
- Plant Physiologist -Tim Artlip

Advanced Production and Automation Systems for Temperate Fruit Crops Through Discovery and Integration

- Tracy Leskey (Lead Scientist) - Entomologist
- Amy Tabb - Engineer
- Lisa Tang - Horticulturist
- Andrew Bierer - Soil Scientist
- Tami Collum -Plant Pathologist
- Vacant - Chemist/Biologist

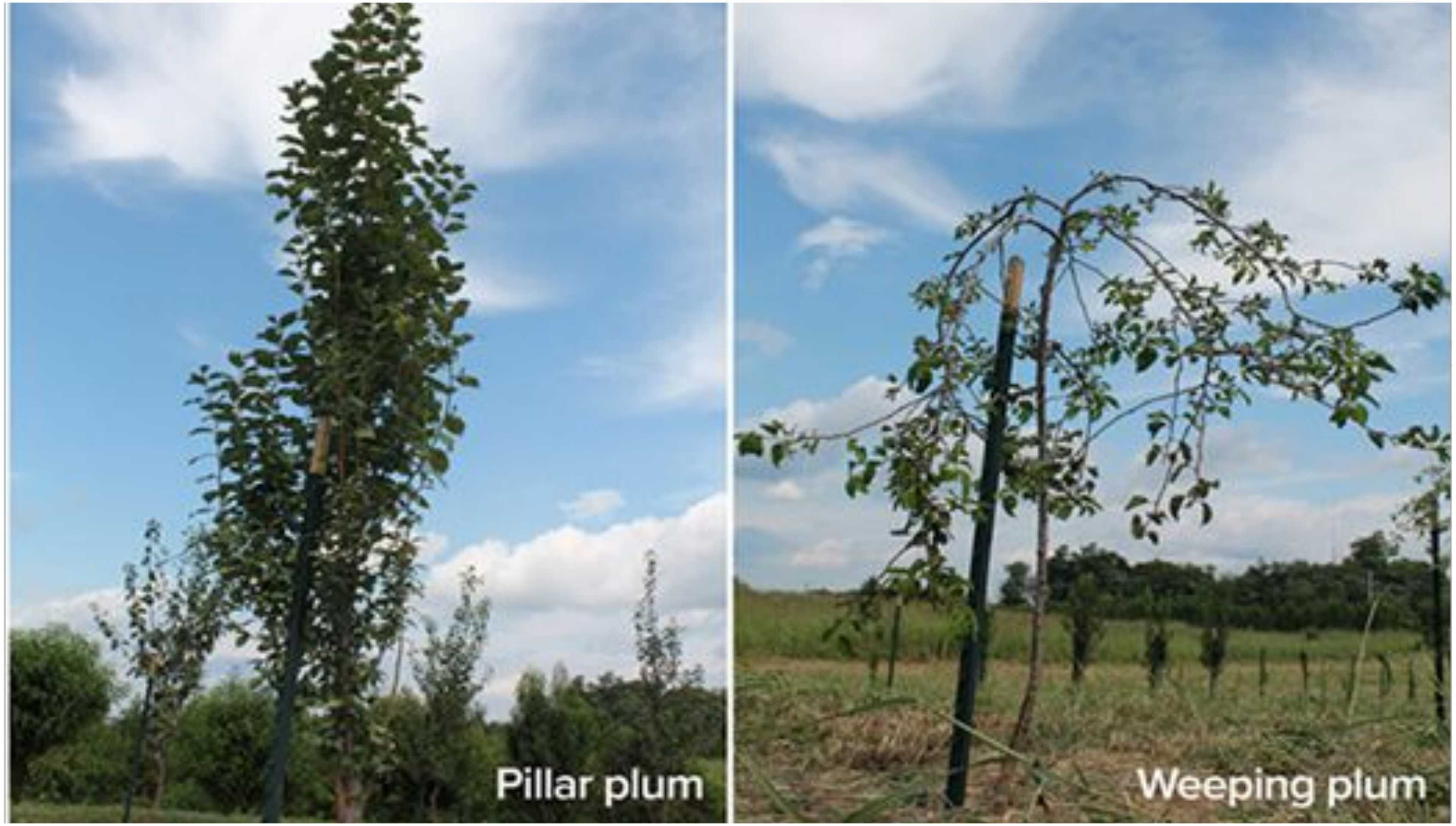
Our Overall Goals

The **Appalachian Fruit Research Station** (AFRS) conducts fundamental, applied and developmental research on critical problems of temperate fruit production.

1. Breeding resilient trees/plants and producing high quality, novel fruit varieties with valuable traits.
2. Developing scalable, equitable management tactics and automation technology.

Impact:
Long-term economic and ecological sustainability

Breeding Resilient Trees/Plants and Producing Novel Fruit Varieties/Traits



Breeding for improved architecture has contributed to massive yield gains in cereal crops.

However, tree and other fruit crop architectures are largely the same…genetically.

Genetic Constraints of Many Fruit Crops

* Many traits are genetically fixed

- Slow growing
- Large size
- Complex environmental requirements
- Dormancy
- Seasonal cropping
- Vegetative propagation
- Storage
- Slow fruit development and ripening times

Management of fruit tree architecture is costly and labor intensive.

- Pruning
- Training
- Trellising
- Dwarfing rootstocks
- Chemical sprays
- Flower/fruit thinning
- Harvesting
- Land/water use

C. Dardick

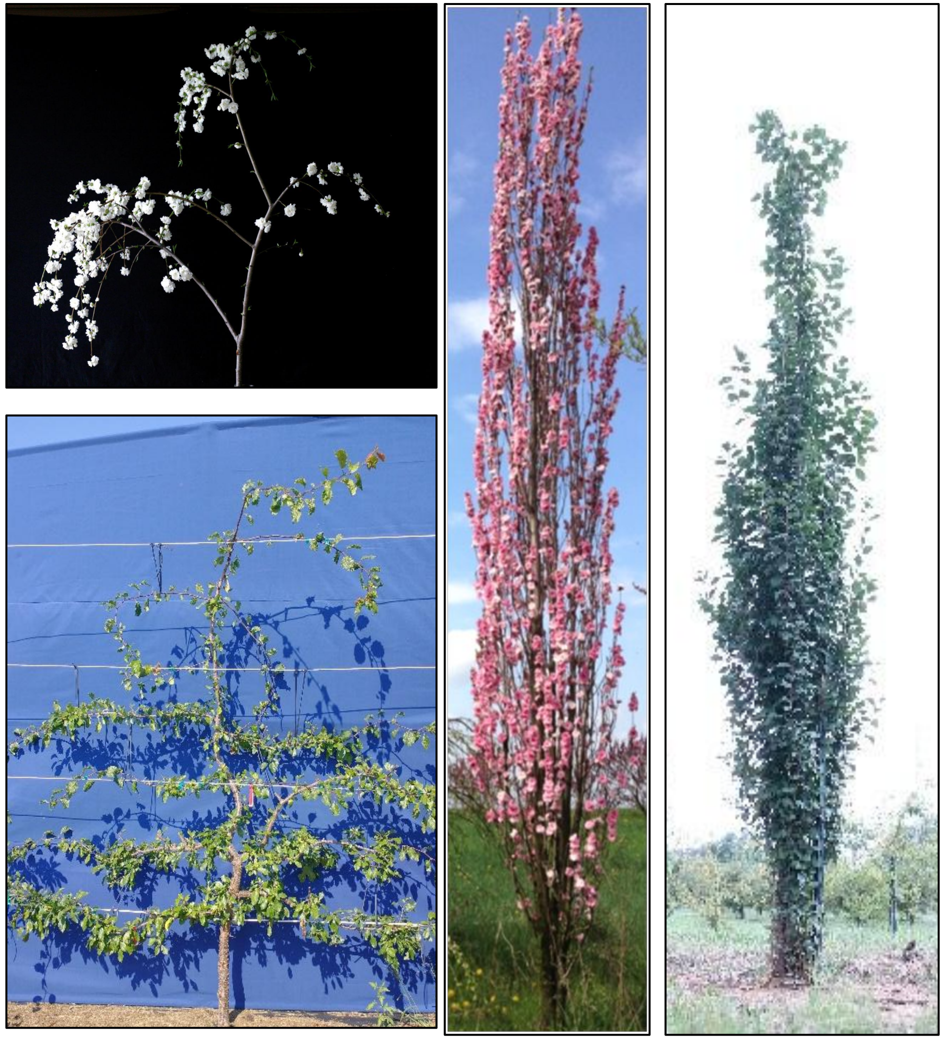
Breeding tree shapes for farms of the future

Branching patterns

Rooting depth

Leaf angles

Branch orientations



C. Dardick

Loss of the *TAC1* gene leads to upright branch angles.

Yu et al, 2007

rice

Ku et al, 2011

maize

Dardick et al, 2013

Arabidopsis

Hollender et al. 2018

plum

González-Arcos et al. 2019

tomato

Fladung et al, 2021

poplar

Dutt et al, 2022

Sweet orange

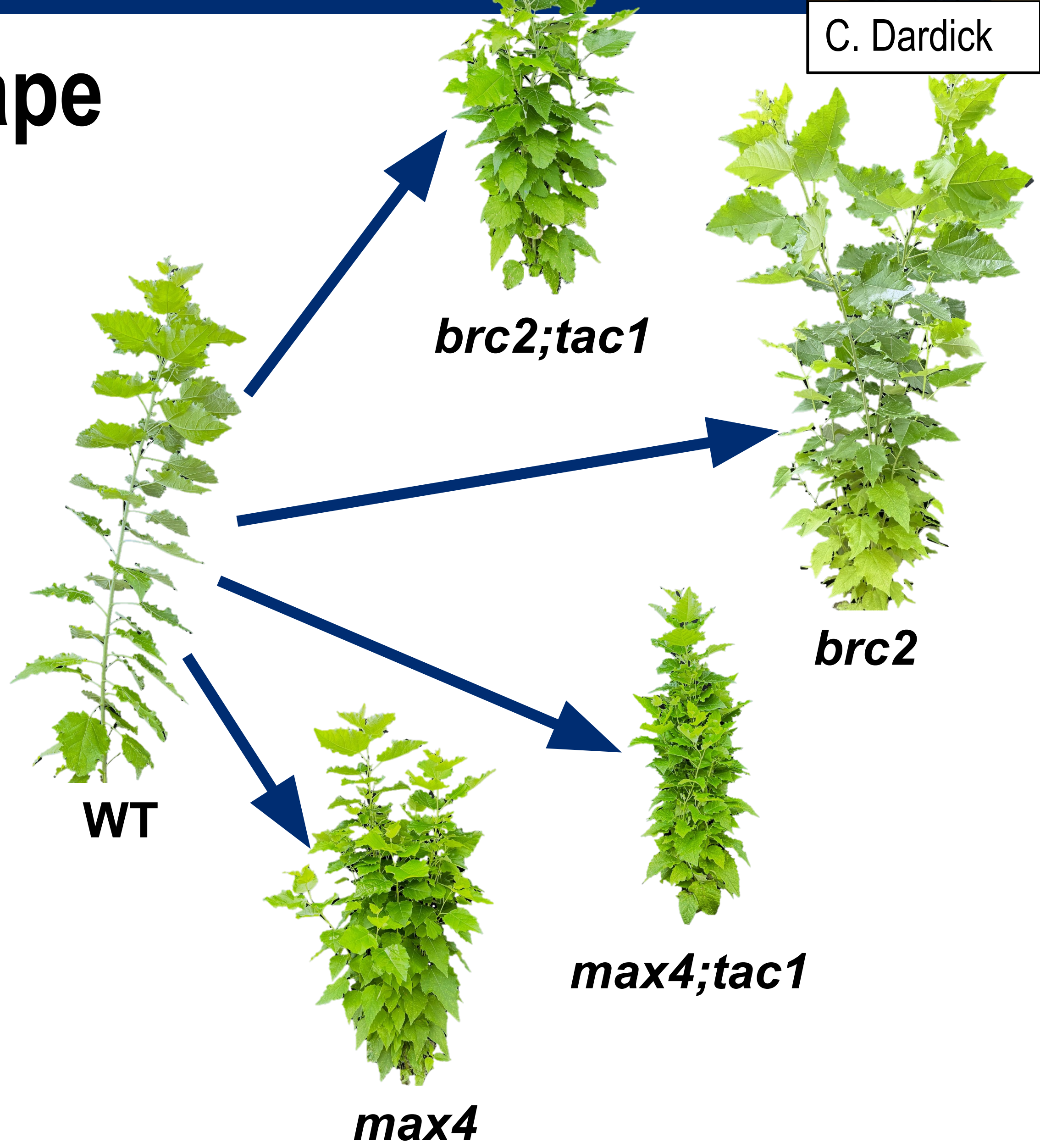
Kagben et al, 2024

Cotton

C. Dardick

Using Genes to Control Tree Shape

- We've adopted poplar as a model to understand genes controlling tree architecture.
  - Poplar is fast growing, easy to propagate, easy to transform, and has high-throughput CRISPR editing .
  - Because this process is so rapid, we can test different genes and combinations in a fraction of the time required in fruit trees.
  - Some morphotypes we've already created are shown at right.
- This helps us pick genes to test in fruit trees.
  - Many of these genes are conserved across species, so what we learn in poplar is broadly applicable to the tree fruit crops
  - The most promising genes creating for a particular shape can then be targeted in tree fruit species where that shape is desirable.



C. Dardick

Fast Track Breeding and Indoor Fruit Production

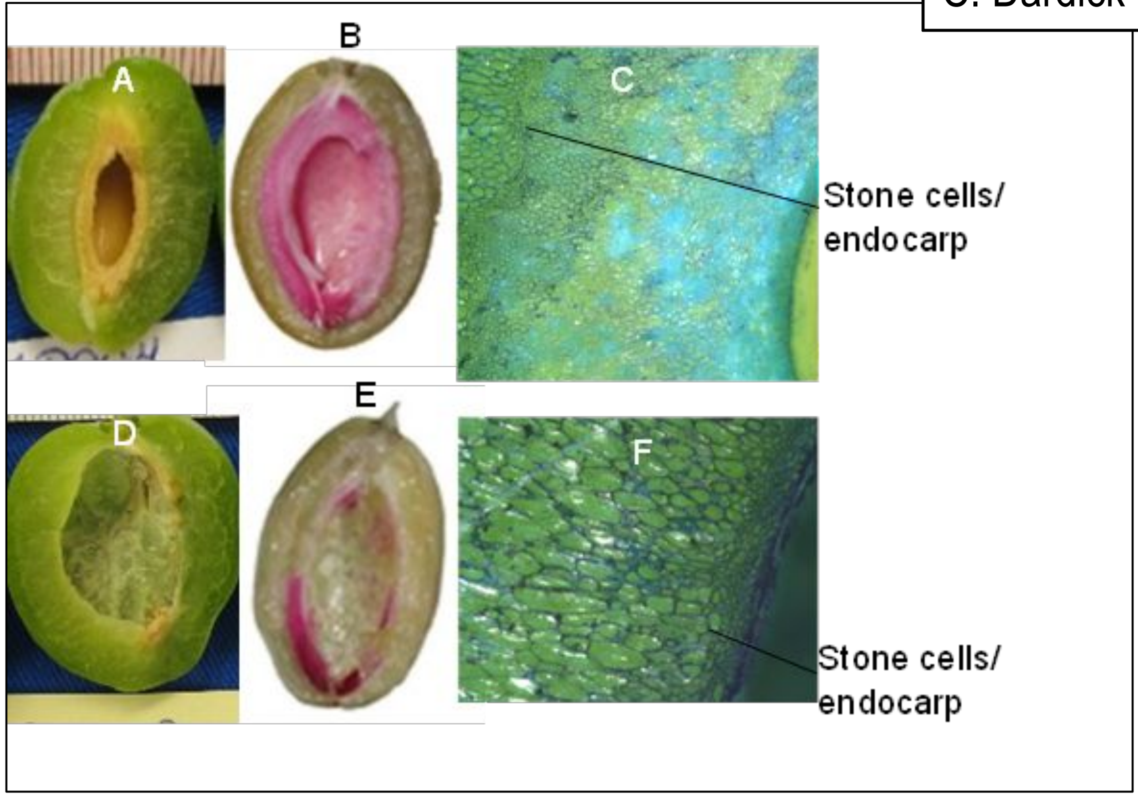
- Small tree size
- Continual flowering
- No dormancy required
- Set fruit year-round
- Can be used to expedite crosses, as no juvenility period.
- Amenable to indoor fruit production.

C. Dardick

Longtime commercial interest in ‘pitless’ traits for crops such as cherry, plum, and blackberry

Normal Stone

‘Stoneless’ accession with decreased lignin and stone cells.

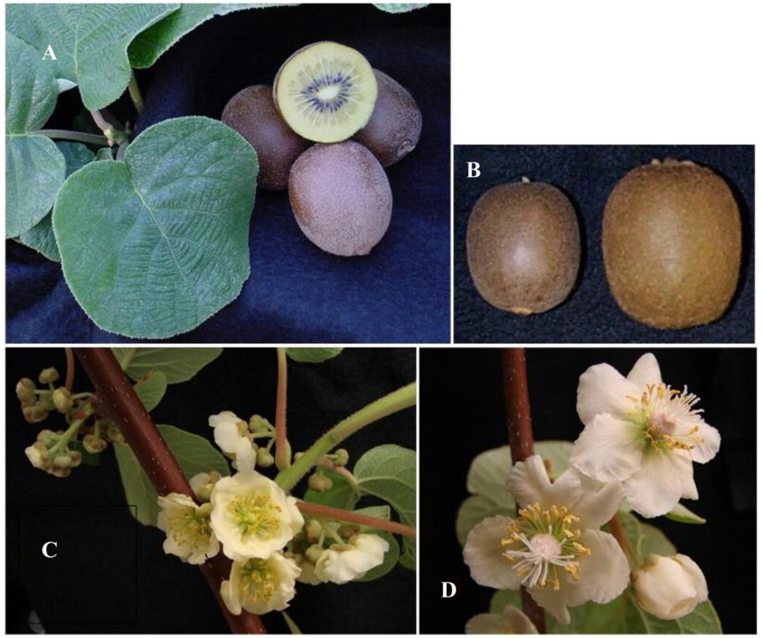


The goal of this research is to map and identify the gene underlying a pitless trait in plum and develop technology to engineer pitless traits in other stone fruits.

T. Artlip

Cold-Hardy Kiwis

- Kiwis are very nutritious, with high levels of vitamin C.
- Most kiwis are subtropical and are not cold tolerant.
- The female ‘Tango’ variety was developed at the AFRS and is a cold tolerant vine.
- Requires the male ‘Hombre’ variety for successful pollination.
- These are vigorous vines, require little to no pruning, and needed no additional fertilizer or pesticides. Strong fruiters.
- Should thrive in mid-Atlantic and Northeastern winters.



Harnessing Crop Wild Relatives Genetics to Broaden the Regions of Production and Promote Plant Resiliency

C. Gottschalk

Habitat diversity of native apples

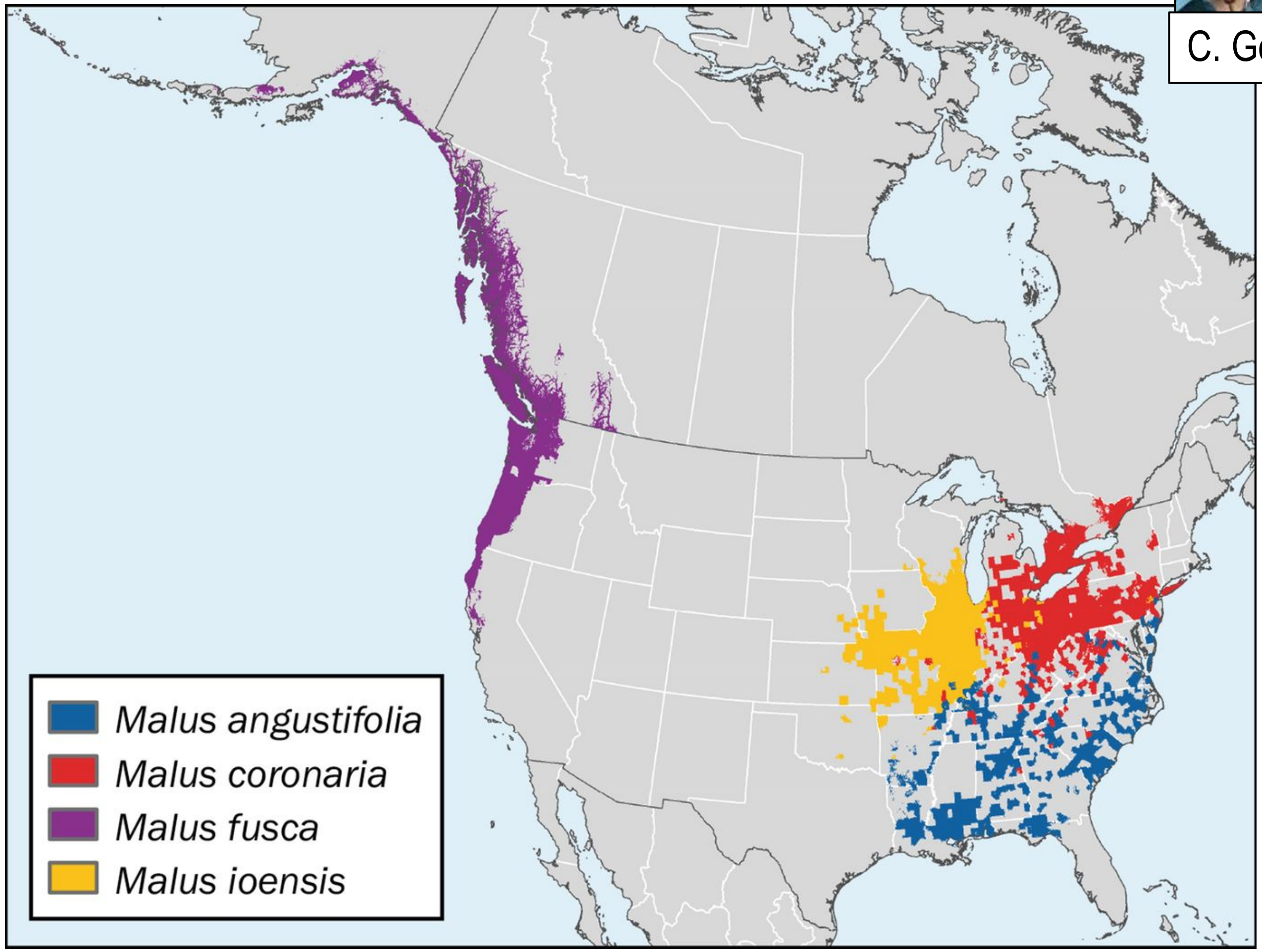
These wild crop relatives offer novelty such as:

Abiotic resilience traits

- Heat stress
- Drought
- Waterlogging
- Salt tolerance
- Cold hardiness

Other important traits

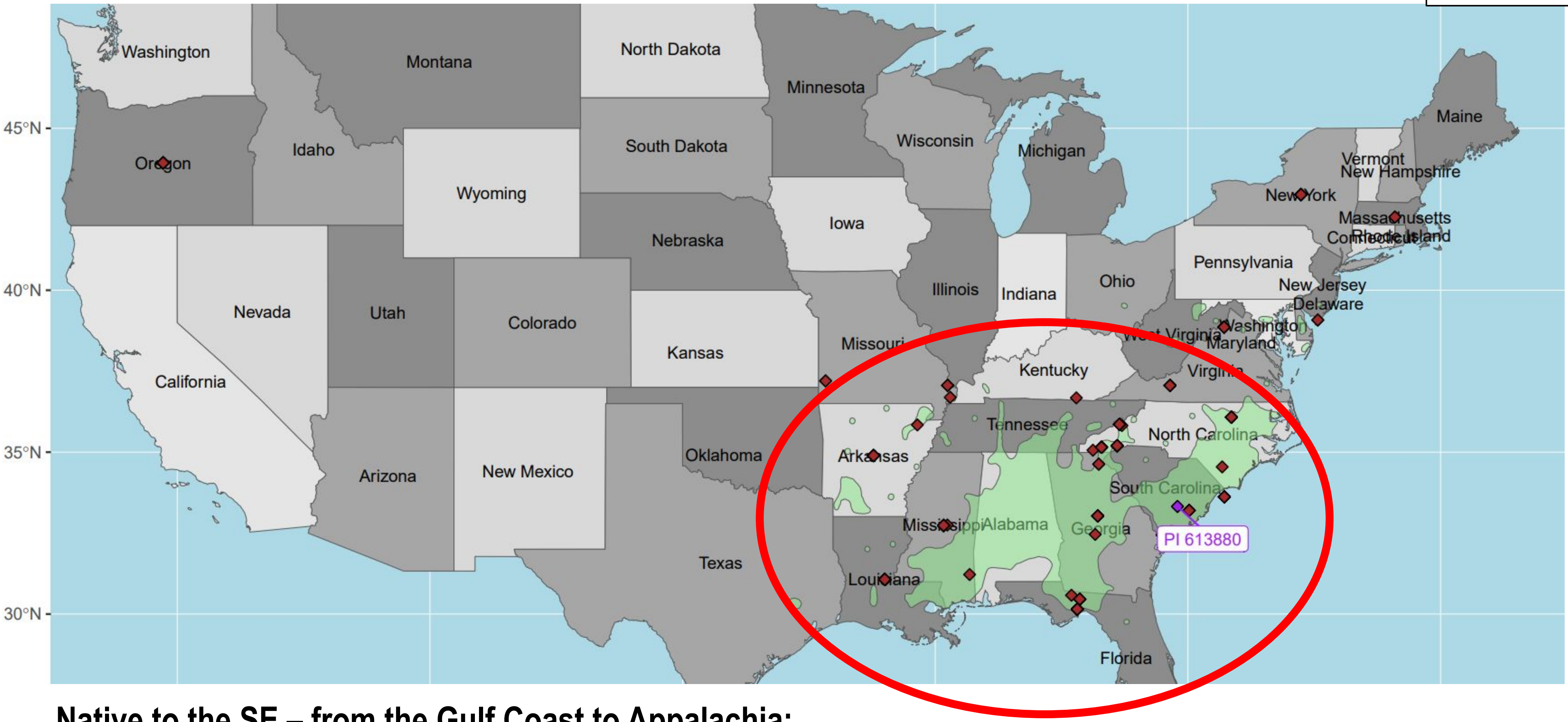
- Bloom times
- Disease resistance



Volk G.M. (2019) Temperate Tree Fruits of North America: *Malus* Mill., *Prunus* L., *Diospyros* L., and *Asimina* Adans. In: Greene S., Williams K., Khoury C., Kantar M., Marek L. (eds) North American Crop Wild Relatives, Volume 2. Springer, Cham. https://doi.org/10.1007/978-3-319-97121-6_11
Gottschalk C and van Nocker S. 2013. Diversity in seasonal bloom time and floral development among apple species and hybrids. JASHS 138(5): 367-374.
Way RD *et al.* 1991. Apples (*Malus*) Acta Hortic. 290: 3-46.

C. Gottschalk

Using *M. angustifolia* germplasm



Native to the SE – from the Gulf Coast to Appalachia; East along the Southern Atlantic Coast to West through the Ozarks

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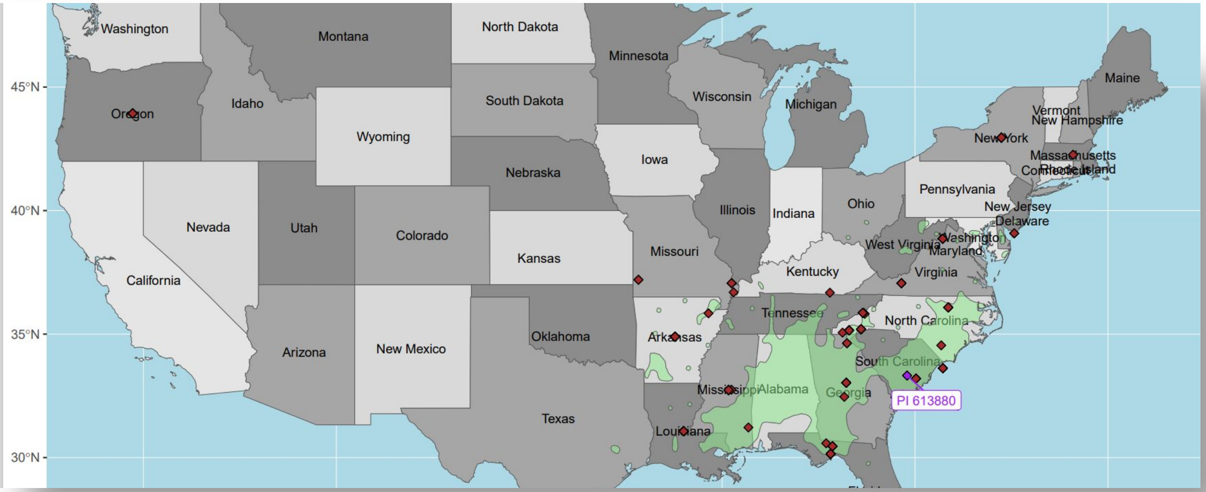
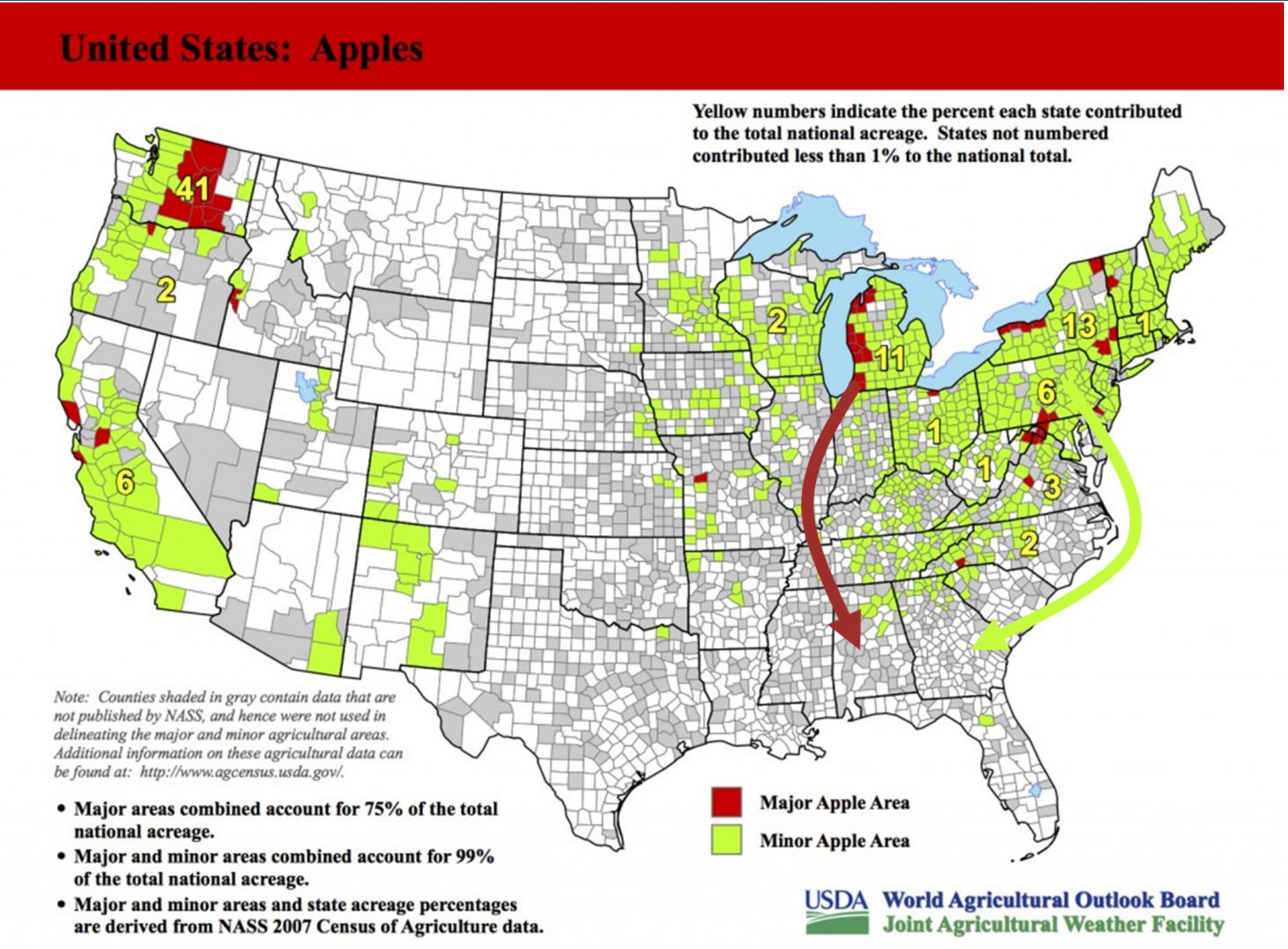
Expanding the USDA *M. angustifolia* germplasm resources

- Generated >70 full- to half-sib populations
- Spans entire native range
- Tremendously diverse





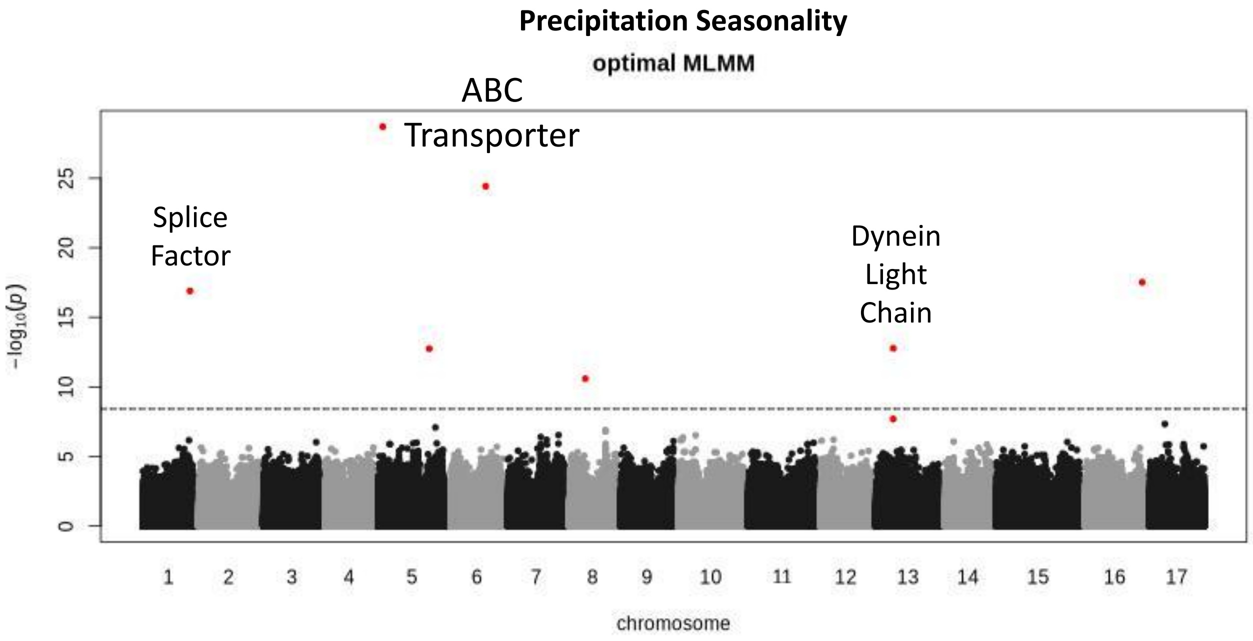
C. Gottschalk

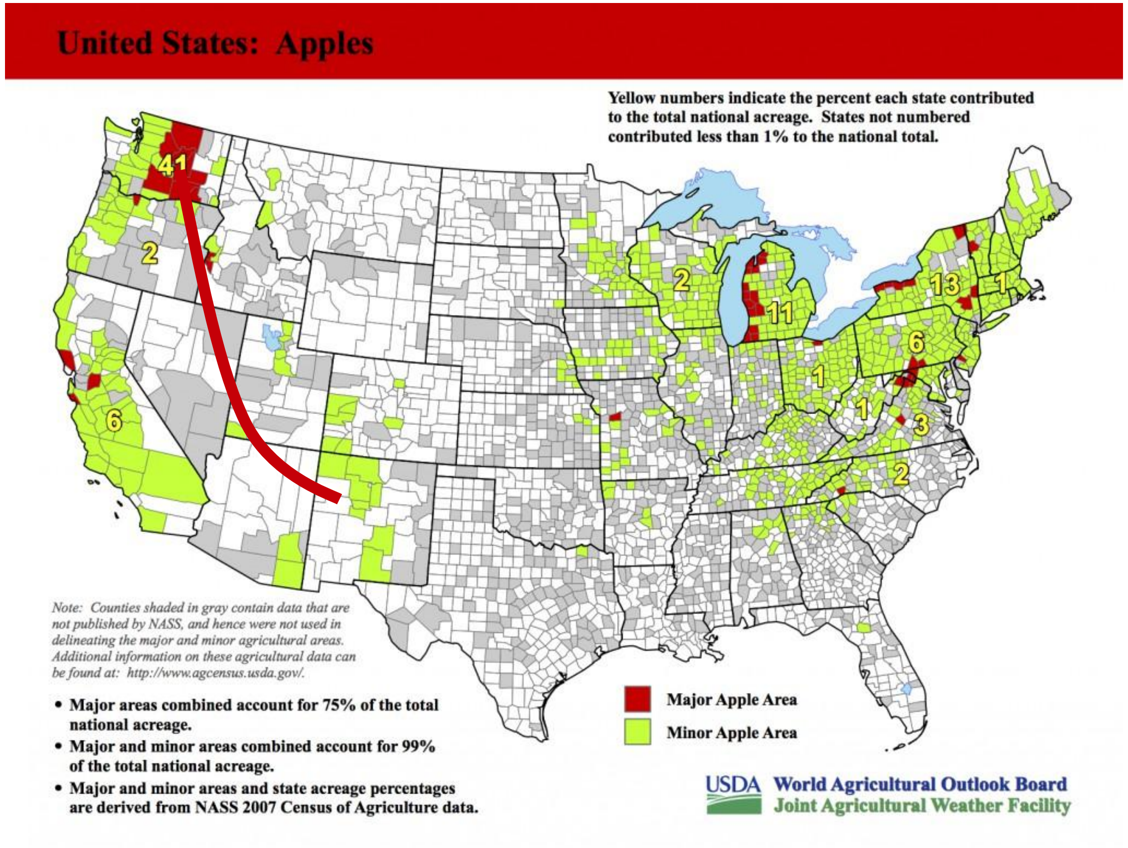
Using *M. angustifolia* germplasm to bring apple production South

M. Angustifolia hybrids could open new production regions in the SE and/or provide resiliency under climate change scenarios

C. Gottschalk

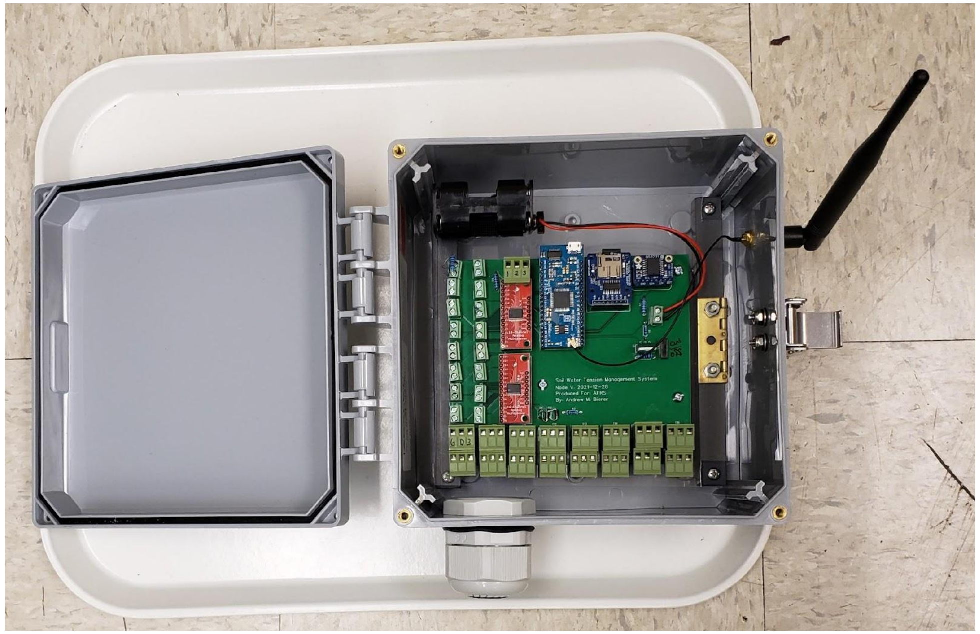
Combining E-GWAS with Genomic Selection





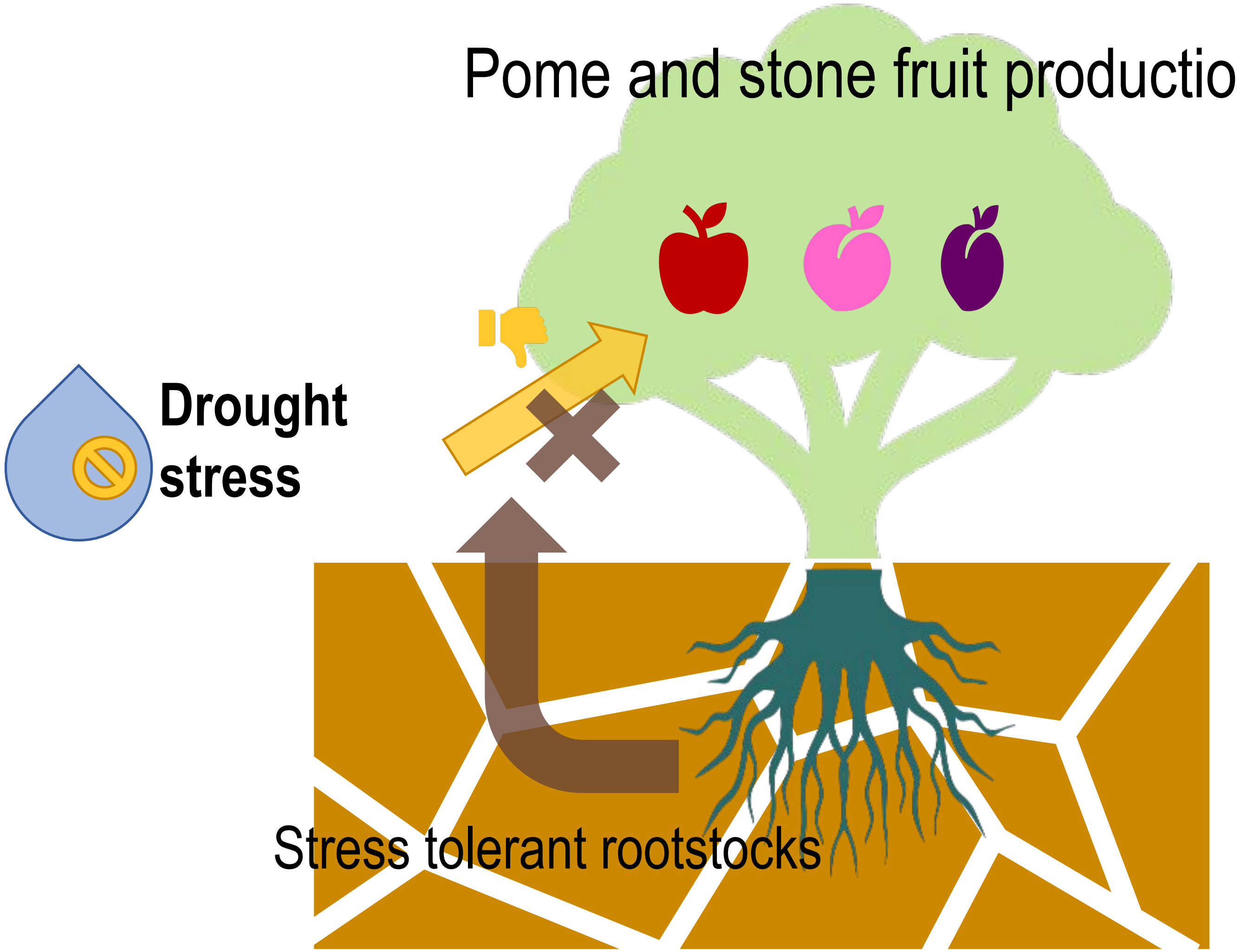
A suite of genetics markers could be used for development of drought resistant apples, opening new production in arid regions of the US or resiliency under climate change scenarios

Scalable, Equitable Management Tactics and Automation Technology



L. Tang

Sustainable fruit production under abiotic stress conditions (drought)



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L. Tang

Non-destructive real-time visualization of tree root system

L. Tang

Root phenotyping using novel soil-less aeroponics and transparent culture media

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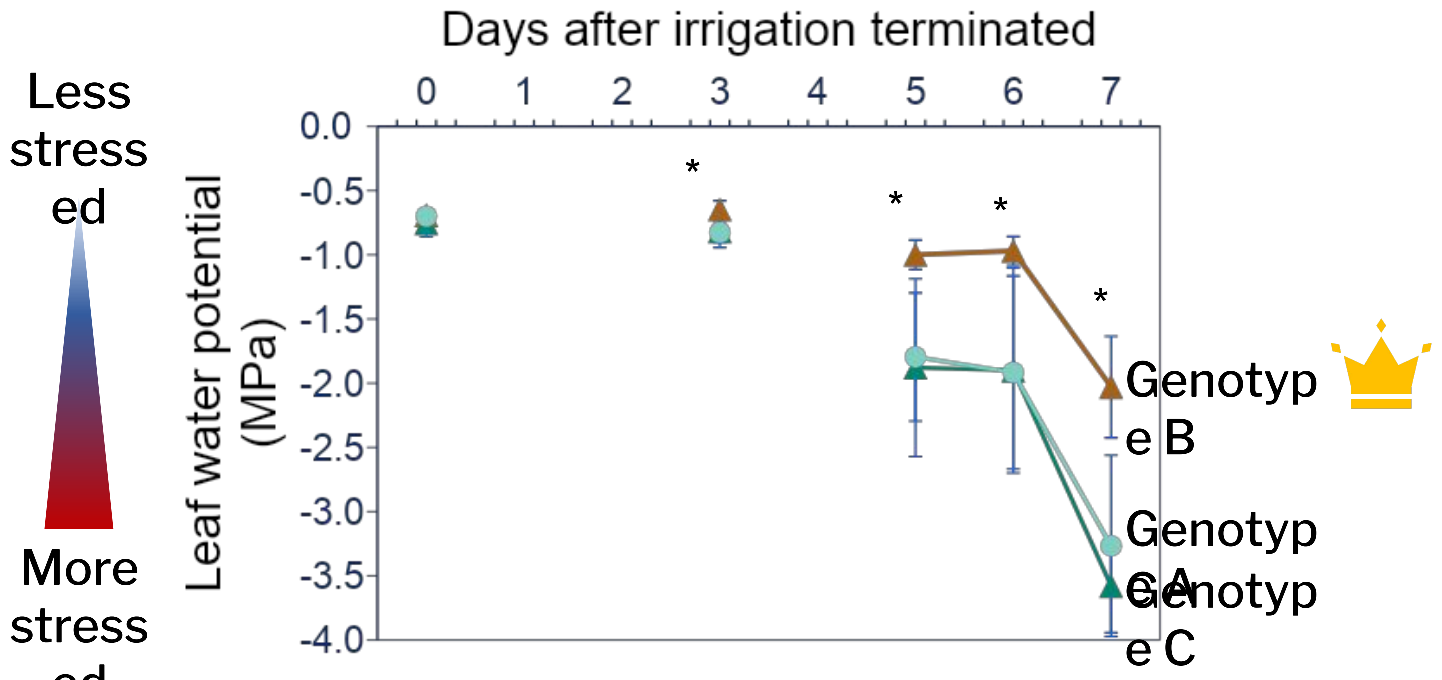
Screening apple rootstock genotypes for drought stress tolerance and investigating underlying physiological and molecular mechanisms



T. Collum

New Varieties With Disease Resistance

Blue Mold | Bitter Rot | Water only

Golden Delicious

PI 369855

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T. Collum

New Varieties With Disease Resistance from Germplasm Collections and Advanced Selections

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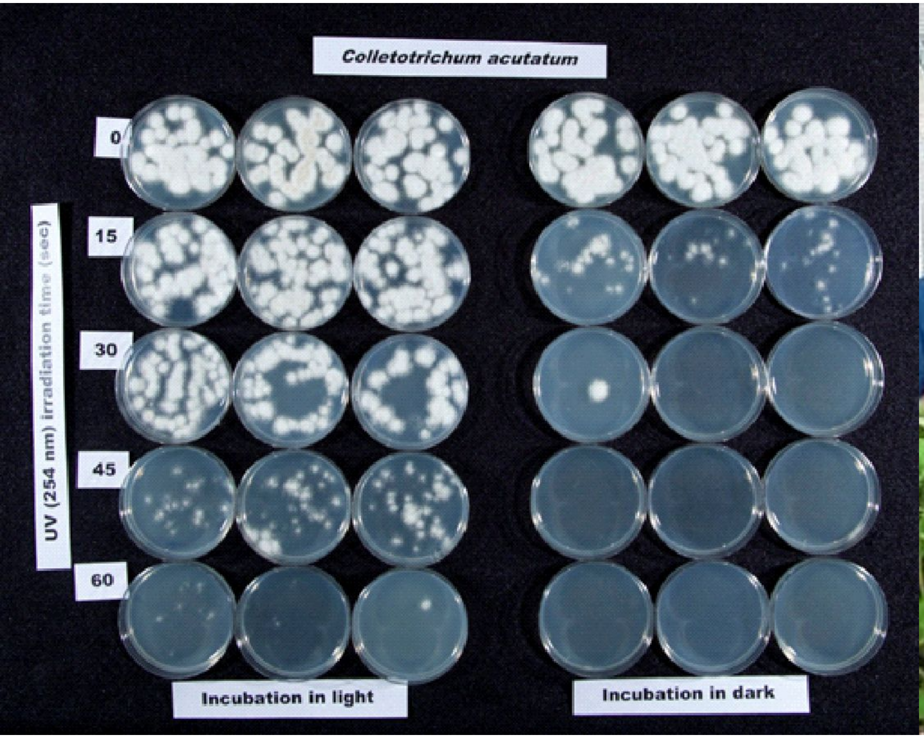
Sustainable Disease Management Tools

T. Collum

Expanding UV-C and far UV to additional fruit crops systems and testing efficacy against diverse plant pathogens and pests

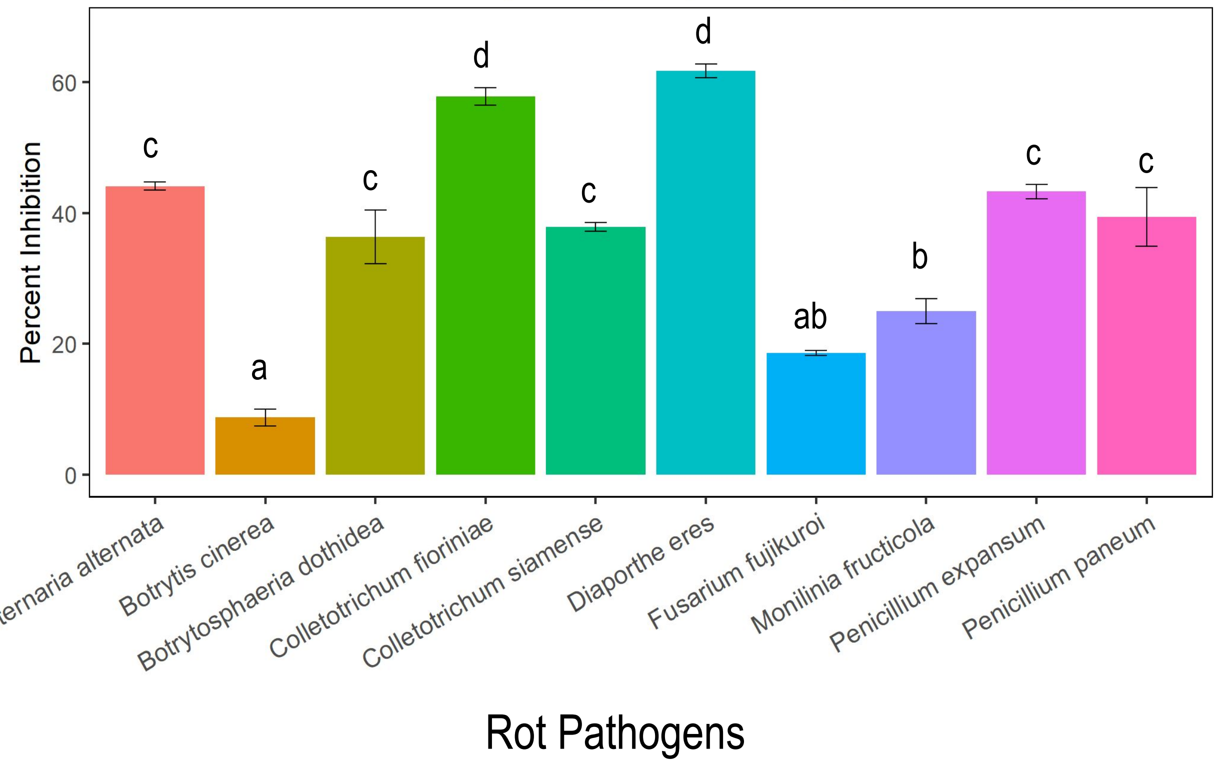


2023 LUNA – TRIC Robotics

T. Collum

New Generation of Biorational Fungicides

Testing microorganisms and biocontrol products for control of post-harvest rots on apple and pear fruit.



No pathogen

Pathogen

Streptomyces + Pathogen

Fruit inoculation with *Colletotrichum fioriniae* casual agent of bitter rot

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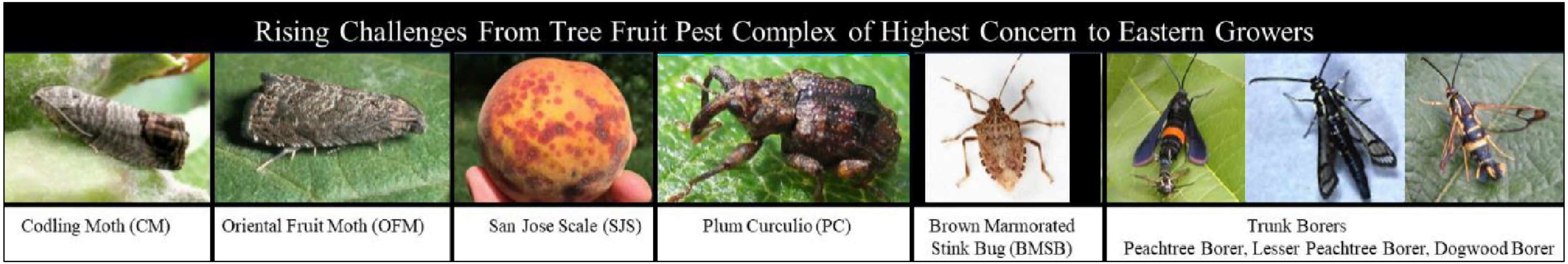
New USDA NIFA SCRI Project: *Cultivating Tomorrow's Orchard: Evolving and Enhancing IPM in Eastern Tree Fruit Systems*

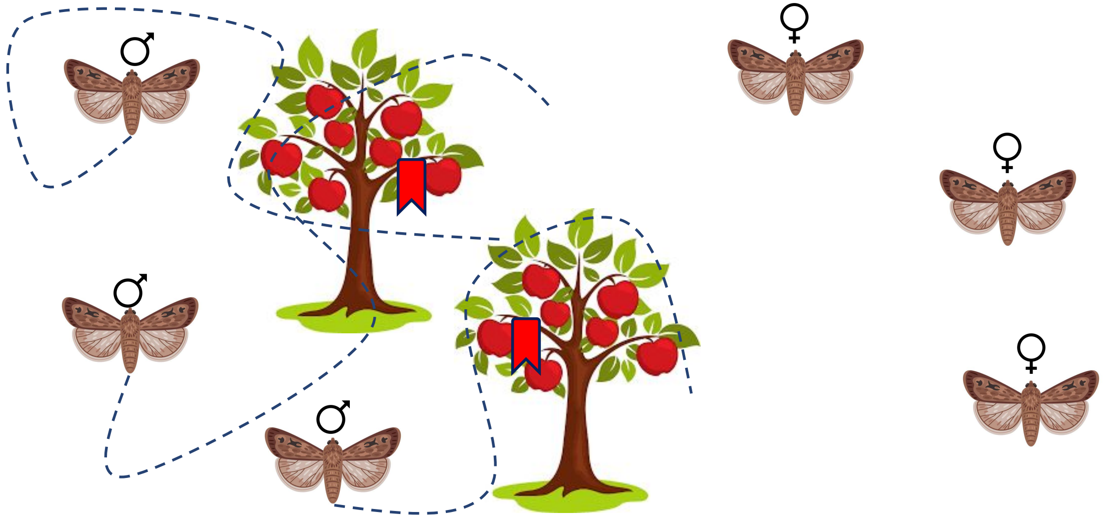


Objectives:

1) measure phenological shifts of these key pests and evaluate reliability of available monitoring tools and models;
2) refine IPM tools to ensure compatibility with evolving production practices, regulatory changes, and climate;
3) suppress pest populationsacross orchard agroecosystems with promising biocontrol agents and integrate enhanced IPM tactics;
4) assess the socioeconomic impact of enhanced IPM programs to promote grower adoption and market flexibility.

USDA-ARS | UMASS | Rutgers | Cornell | Michigan State | Univ Wisconsin | UGA | NC State | Univ Minnesota

Scalable Mating Disruption for Noncompliant Orchards



- Key orchard pest species have well established, synthetically producible female-produced sex pheromones:
  - Codling moth = codlemone (*E*,*E*-8,10-dodecadienol)
  - Oriental fruit moth = Carboxylic ester mixture (*Z*-8-dodecenyl acetate major component)

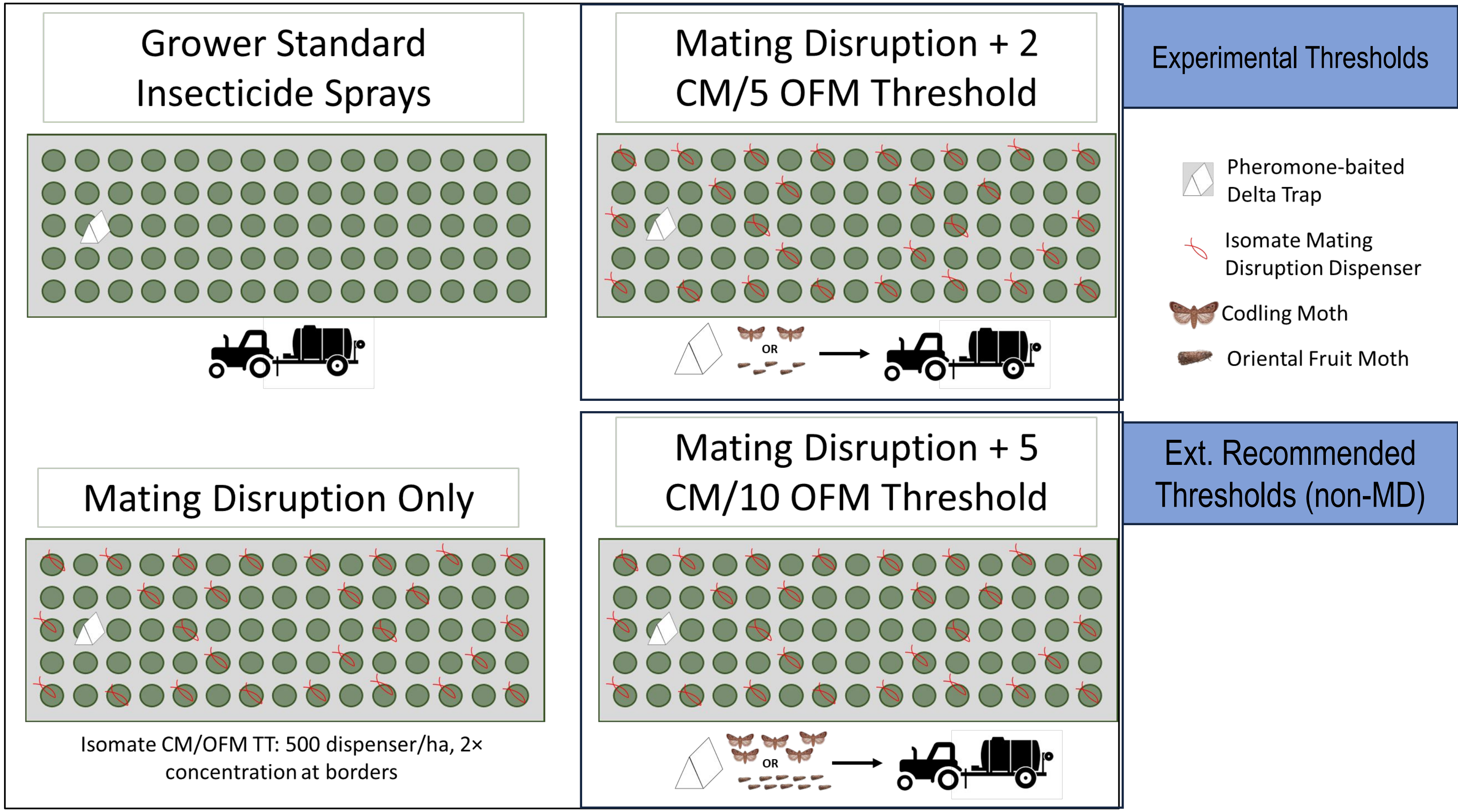
Compliant Orchards must be:

- flat topography.
- square in shape.
- isolated to avoid dispersal of mated females.
- minimum 1.2 – 3 ha.

Orchard borders are vulnerable to depletion of pheromone concentrations by wind ⟶ double mating disruption concentration.

Integrating Threshold-Based Sprays With Mating Disruption for NonCompliant Blocks

- April: Deployed mating disruption ties (Isomate CM/OFM TT) and 2 monitoring traps per block.
- All blocks “non-compliant”.
- Based threshold sprays on weekly captures.
- July: Deployed OFM mating disruption ties.
- September: Fruit harvested and evaluated for injury (10 apples/tree, 20 trees/block).



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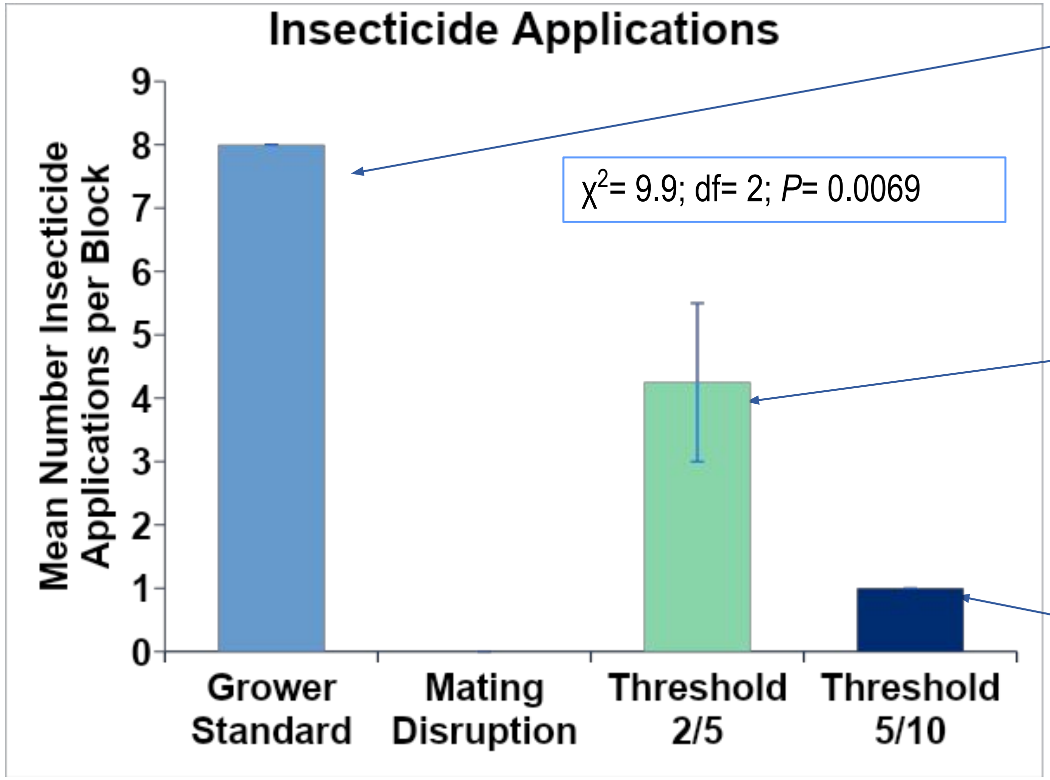
Mating Disruption + Threshold Sprays Reduced Insecticide Applications ~50%



1 Petal fall spray + 7 cover sprays

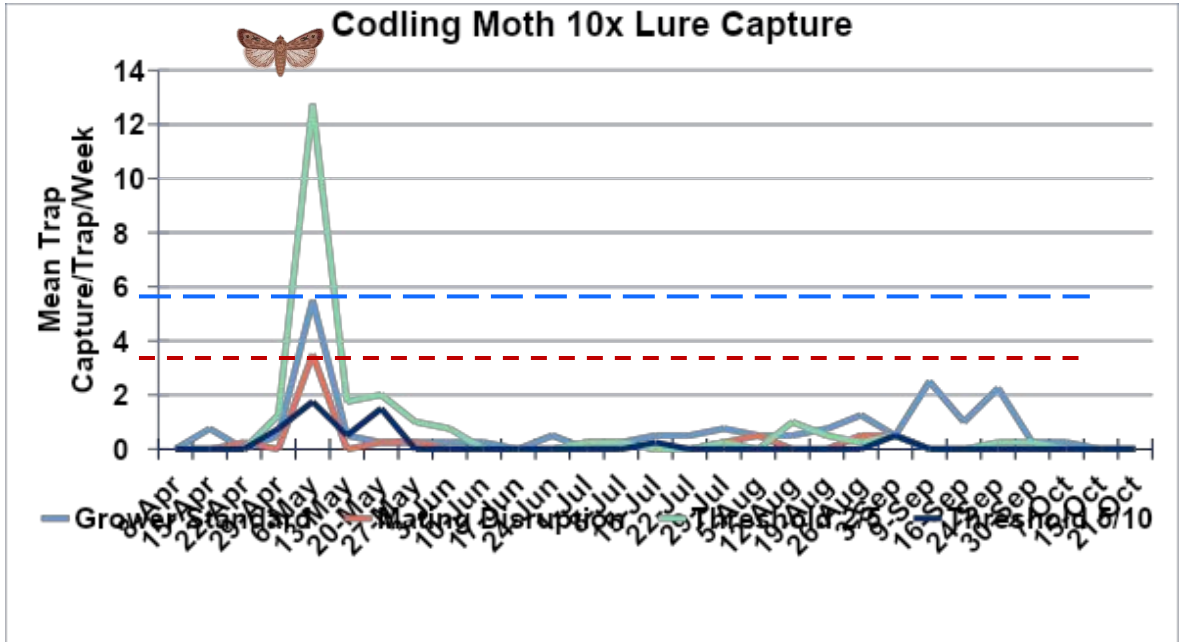
1 Petal fall spray + 2-6 threshold-triggered sprays

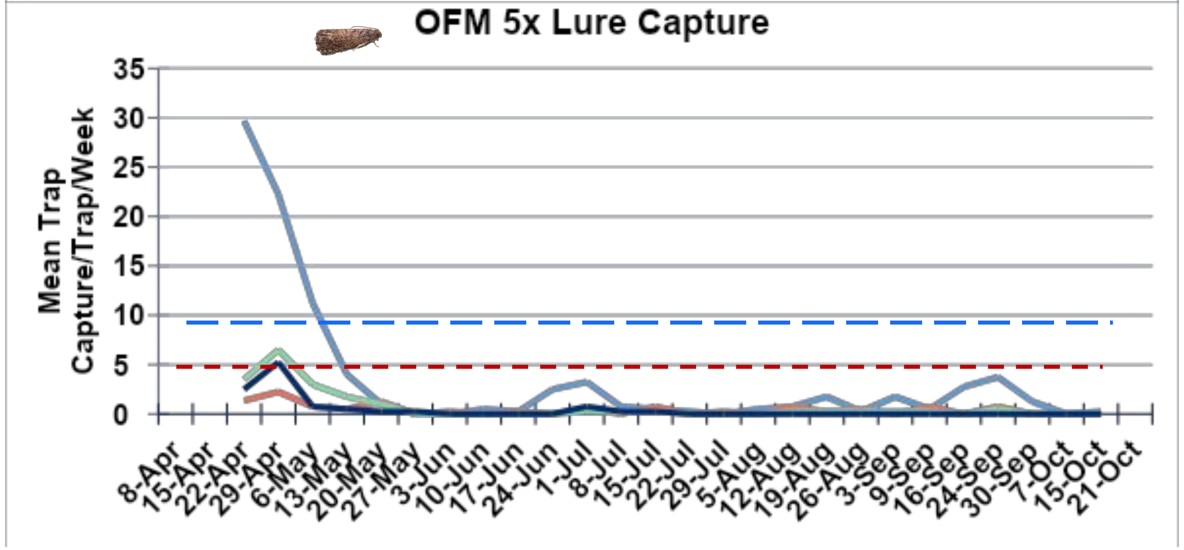
1 Petal fall spray

ALL THRESHOLD SPRAYS TRIGGERED BY CODLING MOTH ONLY

***mating disruption treatment with no sprays applied, not included in analysis.**

Sprays driven by codling moth in problem blocks and using lower, experimental threshold in noncompliant blocks

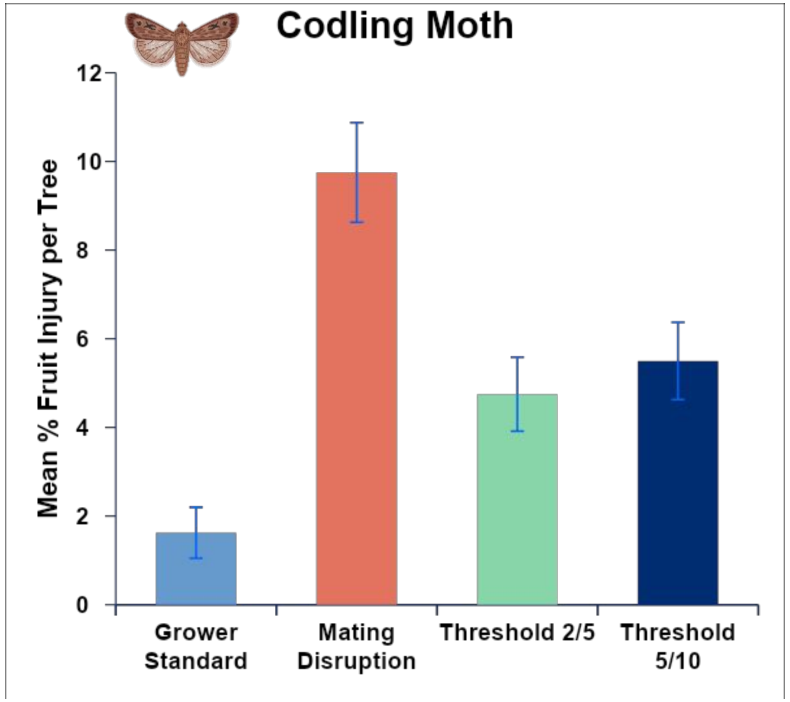


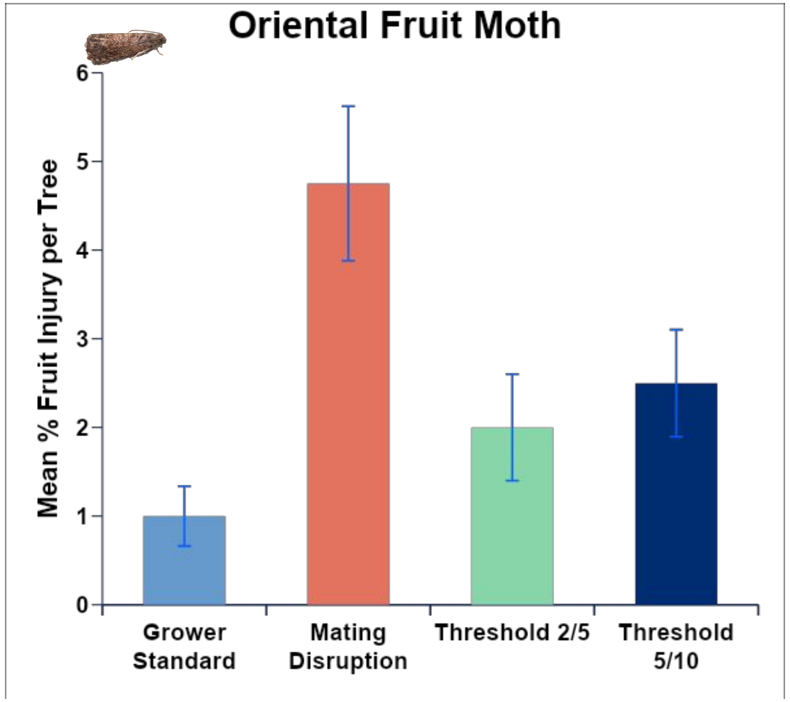


Indicates experimental trap capture threshold of 2 codling moth OR 5 oriental fruit moth.

Indicates standard capture threshold of 5 codling moth OR 10 oriental fruit moth.

Integrating mating disruption with threshold-based insecticide applications reduced codling moth and oriental fruit moth injury to apples by >50% compared with mating disruption alone.





- Injury is 2X previous year across all treatments
- 3 total larvae found (not analyzed)

Key Question

- Can we utilize or enhance existing trap-based tools and incorporate existing DD model to provide a reliable decision support protocol for managing plum curculio in apple?

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PC Lure Study Methods

- Trials conducted in WV at three sites with three replicates per site 14 April-26 September in 2023, and 18 April -19 September in 2024.

- 4 ft black pyramid traps spaced at least 50m apart in border rows/outside border rows next to wood lines. Weekly monitoring and randomization.

Treatments:

- Control
- MeSA+ PHER
- BENZ + PHER
- BENZ+MeSA+PHER (***<u>2024 only</u>***)

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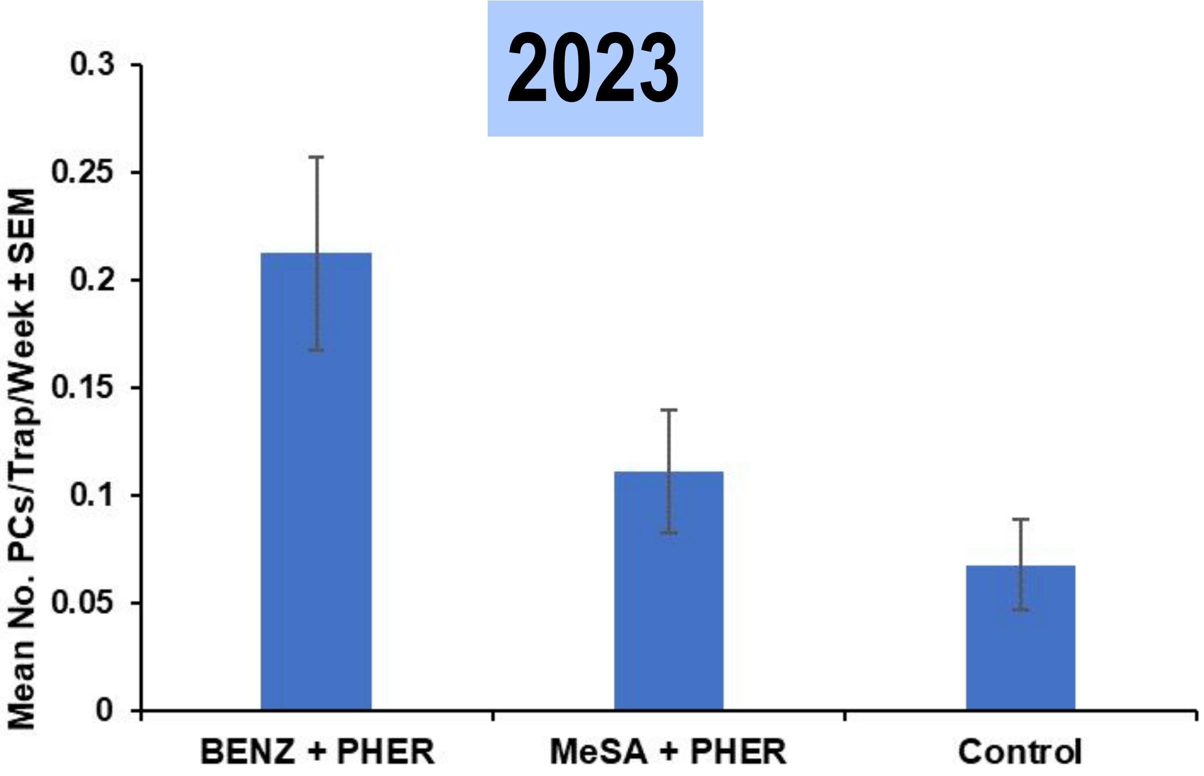
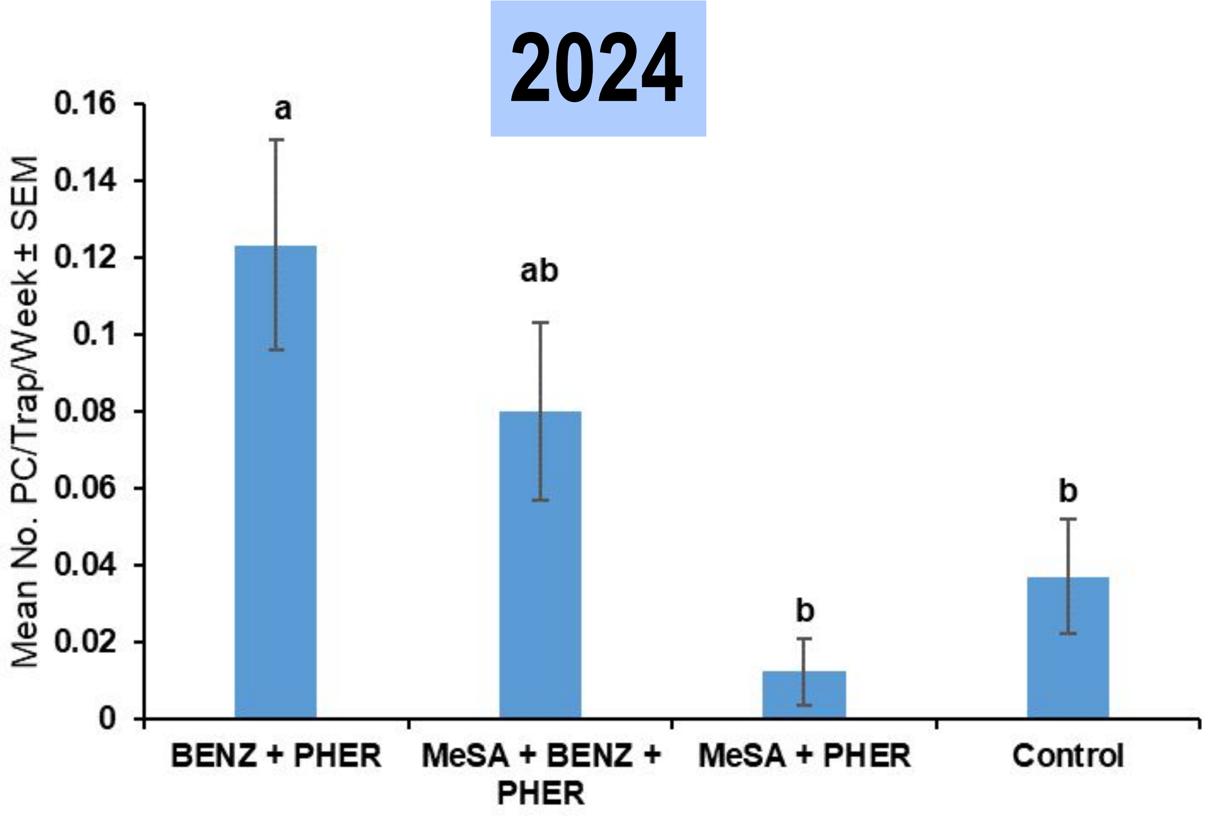
Weekly Trap Captures By Lure Type

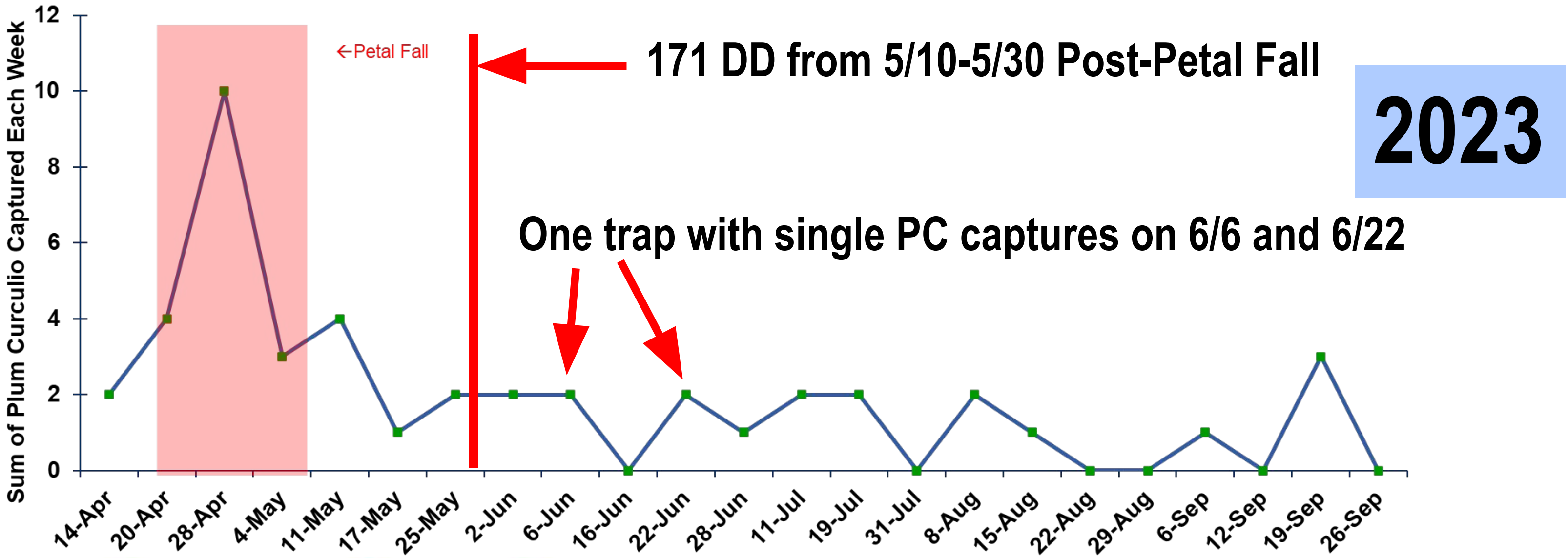


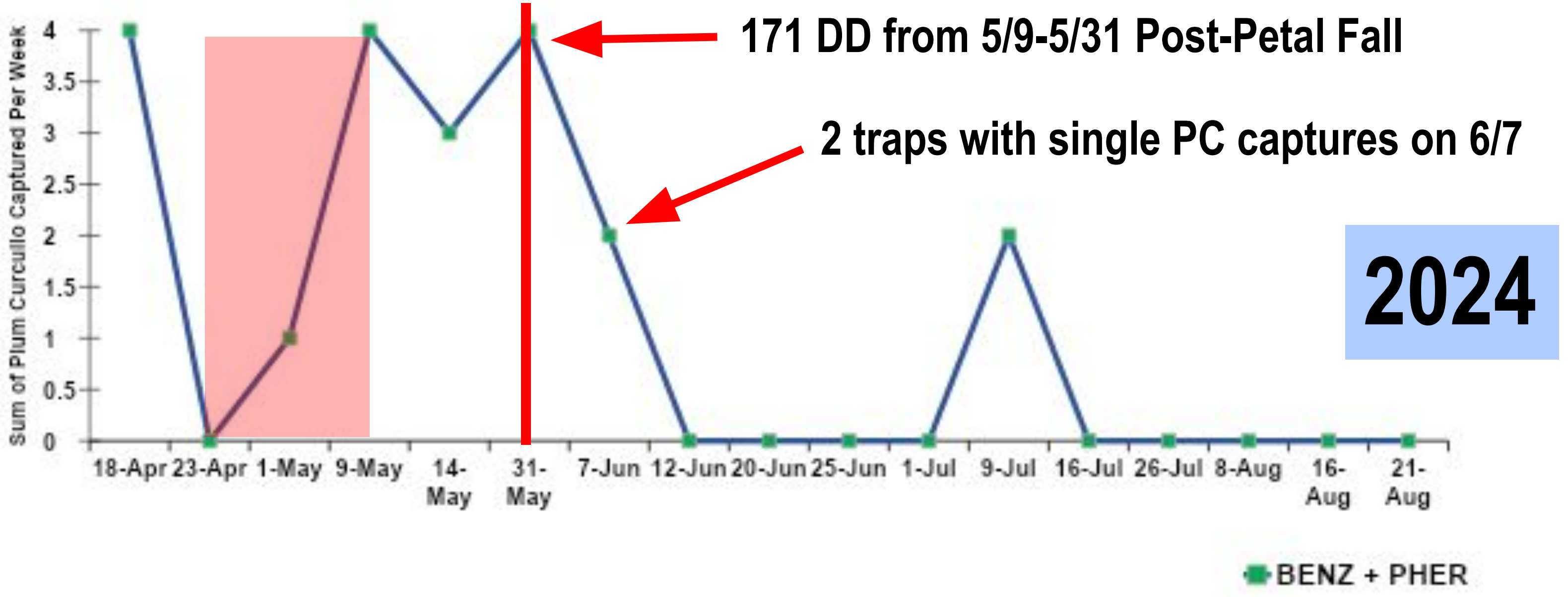


BENZ + PHER remains most attractive lure combo for monitoring PC in the mid-Atlantic.

Season Trapping Phenology and DD Outputs

- For Benz + PHER trap captures, most occur before end of June.
- DD model predicts end of oviposition by the end of May or early June.
- Do those June trap captures matter? Will PC damage apples ~40 mm in diam?





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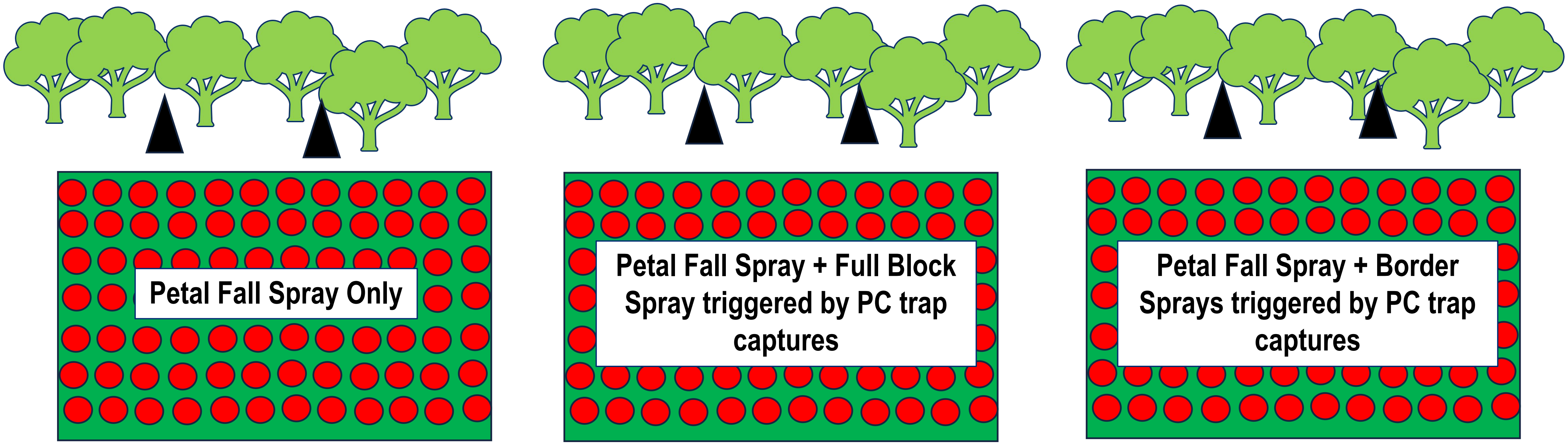
2025 Plans: Evaluate Presence/Absence Threshold and DD To Manage PC in Apple



- Traps baited with Benz+GA deployed next to wood line and checked weekly.
- All plots receive petal fall spray, but two plots have additional full block or border sprays triggered by **presence/absence threshold** in baited traps.
- Assess damage in all plots at 171 DD post-petal fall and cease insecticide sprays.
- Continue to monitor for additional trap captures and fresh oviposition injury until “June drop”.

Alternate Biosurveillance and Monitoring Tools

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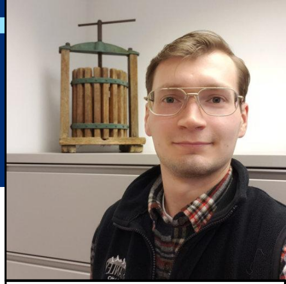


A. Bierer

Development of Scalable, Low-Cost Alternatives Promotes Equity in Temperate Fruit Industry

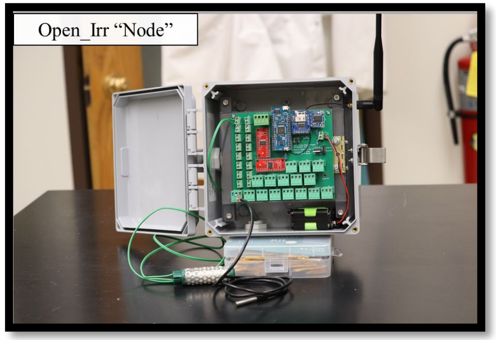
- Actionable monitoring of the plant/environment nexus
- Real-time data generation for improved analytics
    - Real and near-real time responses
- Labor cost reductions
    - Automation in data generation
- Strengthening of the domestic industry from the ground up

Soil Moisture

SapFlow Sensor

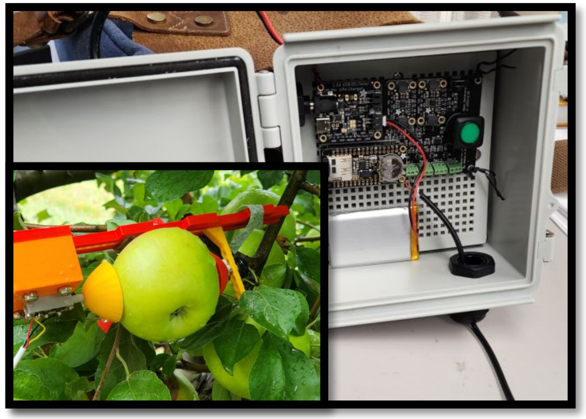
Fruit Size

Soil Moisture



SapFlow Sensor

Fruit Size



Commercial

Open-source & low-cost

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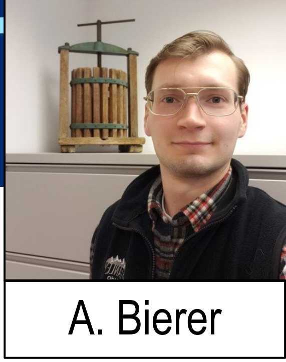
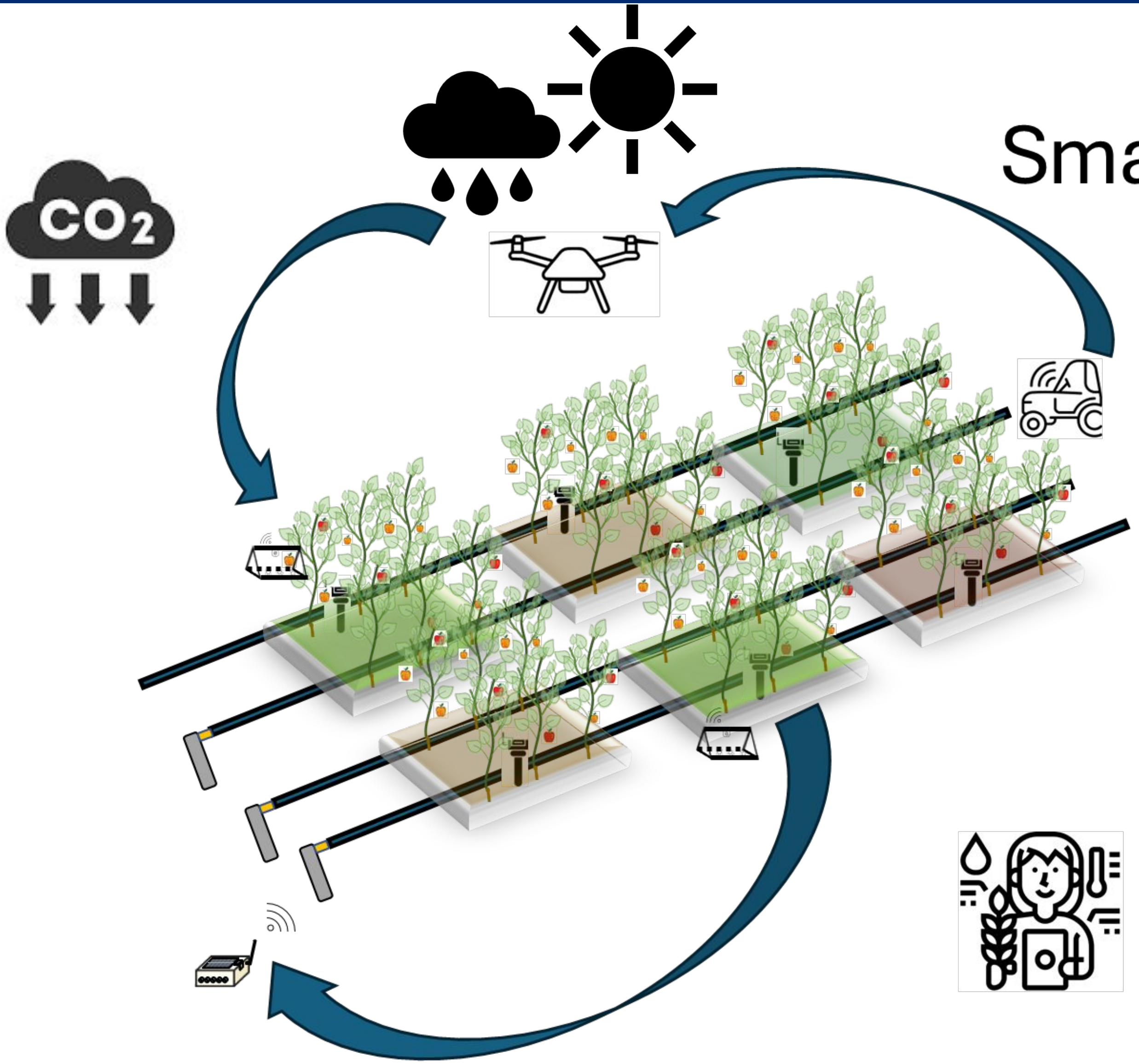
Climate Smart Agricultural Systems





Smart Agricultural Systems

Connectivity, automation, and *feedback loops*

- Precision automated irrigation commensurate with demand
  - Reductions in leached chemistries
  - Lower disease incidence
- Data-driven pest control
  - Automated spray schedules generated for maximizing revenue
- Un-manned management
  - Sprays
  - Irrigation
  - Pest & Disease Monitoring
  - Harvest & Pruning
- **Already in-progress, integration/coalescence of multidisciplinary data-driven systems will follow!**

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Orchard of the Future According to AI (Chat GPT)

1. Smart Farming Technologies
- IoT Sensors: Soil moisture, temperature, and nutrient sensors can provide real-time data to optimize irrigation and fertilization.
- Drones and UAVs: Drones can monitor plant health, assess crop yields, and even assist in pollination or pesticide application.
- Automated Systems: Robotics for planting, pruning, and harvesting can reduce labor costs and increase efficiency.

2. Sustainable Practices
- Permaculture Design: Incorporating permaculture principles to create a self-sustaining ecosystem that supports biodiversity.
- Organic Farming: Utilizing organic methods to reduce chemical inputs, fostering healthier soil and plants.
- Agroforestry: Integrating trees and shrubs with crops to enhance biodiversity, improve soil health, and create habitats for wildlife.

3. Vertical and Urban Orchards
- Vertical Farming: Growing fruit trees in a vertical setup to maximize space, especially in urban areas.
- Container Orchards: Utilizing containers for growing fruit trees in small spaces, making orchards accessible in urban environments.

4. Climate Resilience
- Drought-Resistant Varieties: Developing and planting fruit varieties that are more resilient to climate change, such as heat and drought.
- Microclimates: Designing orchards to create microclimates that protect plants from extreme weather conditions.

5. Data-Driven Decisions
- Predictive Analytics: Using AI and machine learning to analyze data for better forecasting of yields, pest an disease outbreaks.
- Blockchain for Traceability: Implementing blockchain technology to ensure transparency in the food supply chain, from orchard to consumer.

Orchard of the Future According to AI (Chat GPT)

6. Community Engagement
- Educational Programs: Offering workshops and tours to educate the community about sustainable practices and the importance of local food systems.
- Local Markets: Establishing on-site markets or community-supported agriculture (CSA) programs to connect consumers directly with growers.

7. Biodiversity and Ecosystem Services
- Pollinator Gardens: Planting native flowers and plants to attract pollinators and enhance fruit production.
- Integrated Pest Management (IPM): Using beneficial insects and other natural methods to control pests and diseases.

8. Renewable Energy Integration
- Solar Panels: Utilizing solar energy to power irrigation systems, greenhouses, and other facilities within the orchard.
- Wind Turbines: Exploring wind energy as a supplemental power source for the orchard's operational needs.

9. Waste Reduction and Circular Economy
- Composting: Implementing compost systems to recycle organic waste into nutrient-rich soil amendments.
- Bioenergy: Exploring options for converting orchard waste into bioenergy, reducing overall waste and providing additional energy sources.

Conclusion
The Orchard of the Future exemplifies a holistic approach to fruit production, emphasizing sustainability, technology, and community involvement. By integrating innovative practices and advanced technologies, these orchards can thrive in an ever-changing world while contributing positively to the environment and local economies.

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