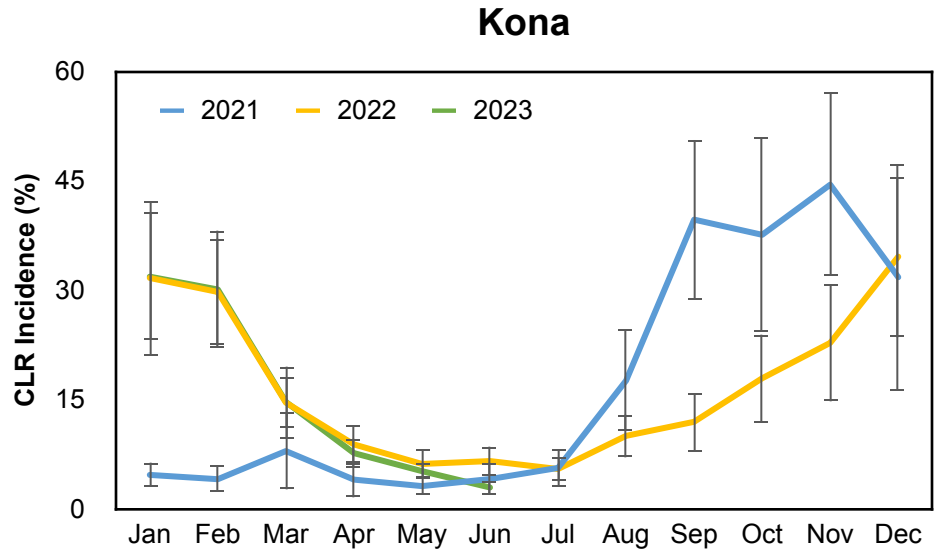
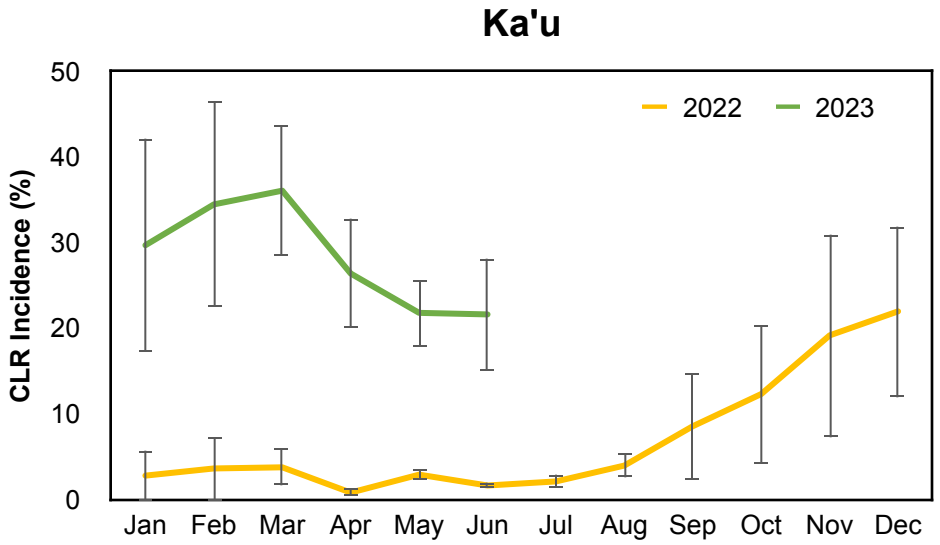
# CLR on Hawaii Island: biology, cultural and chemical control options

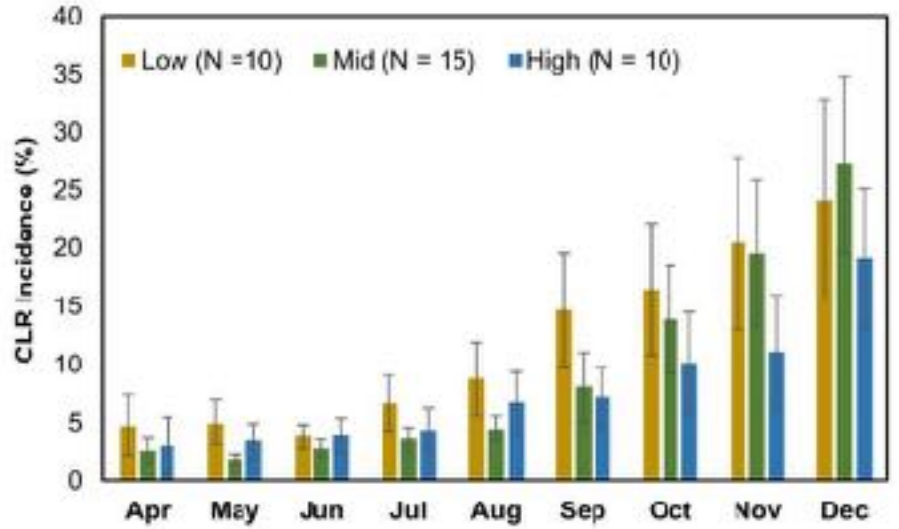
Melissa A. Johnson, Ph.D.

Research Biologist, USDA-ARS DKI US PBARC

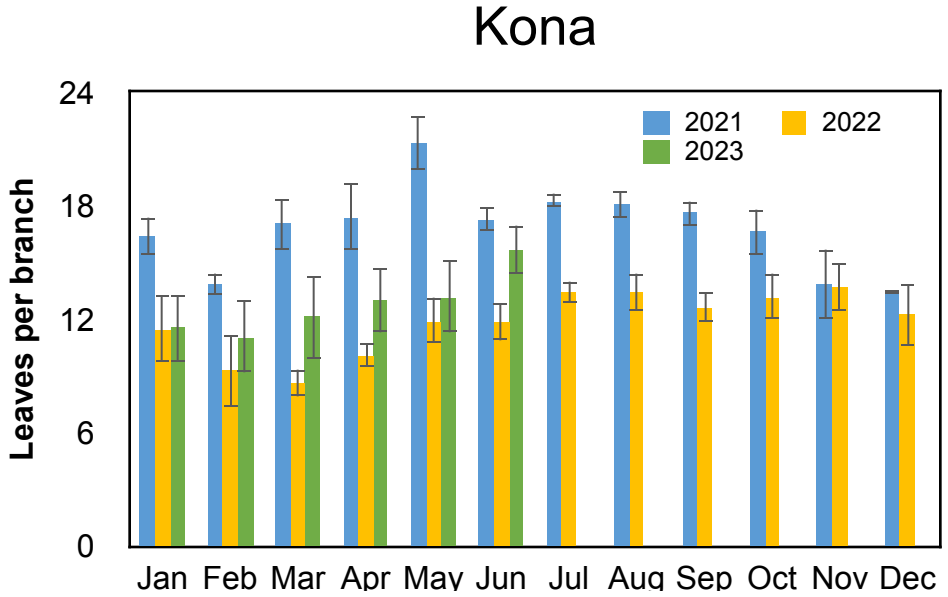
# CLR Incidence across districts and elevation

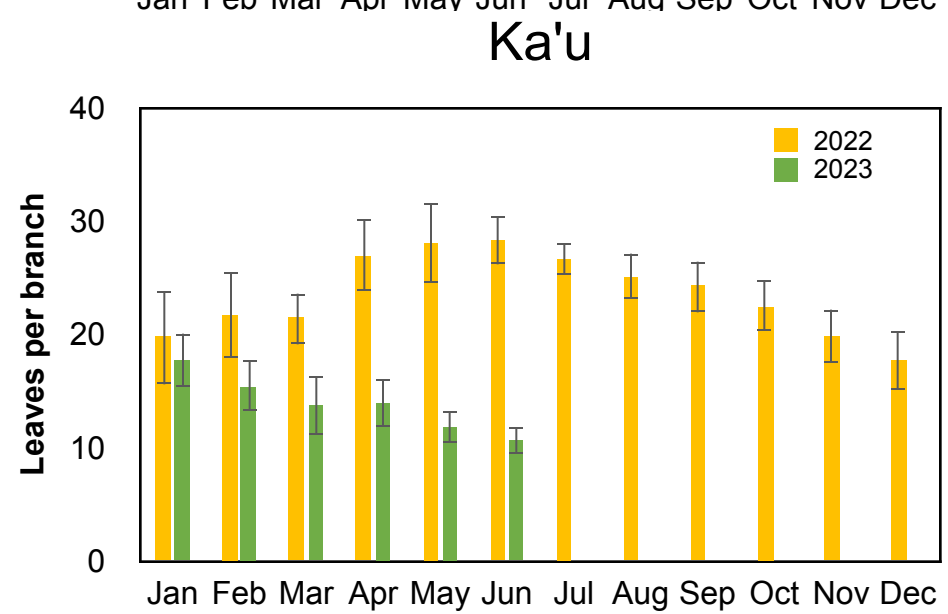


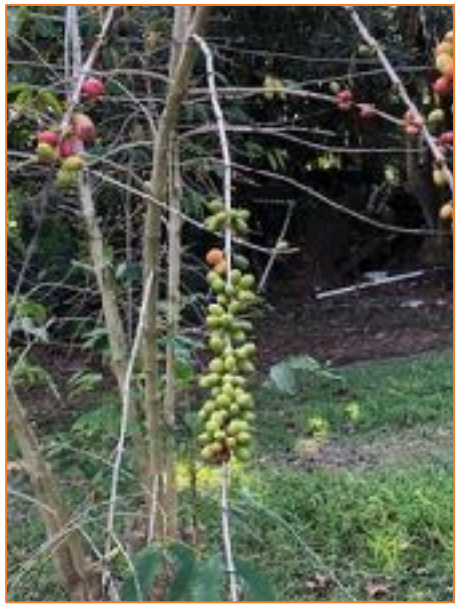




# Leaf Loss over time



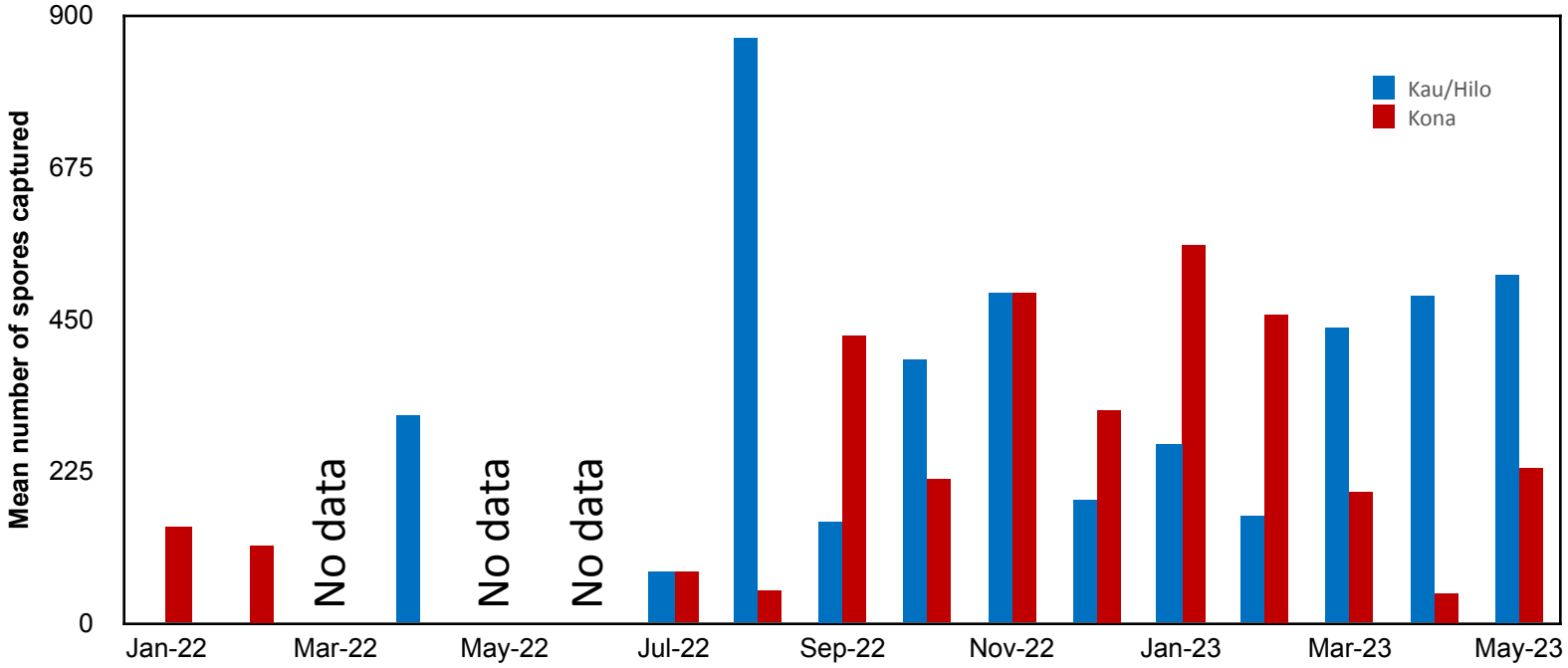



Kona: 30% of leaves lost on average in 2022
18% recovery estimated for 2023

Ka'u: 30-50% of leaves estimated to be lost in 2023
Combination of strong windstorms and CLR

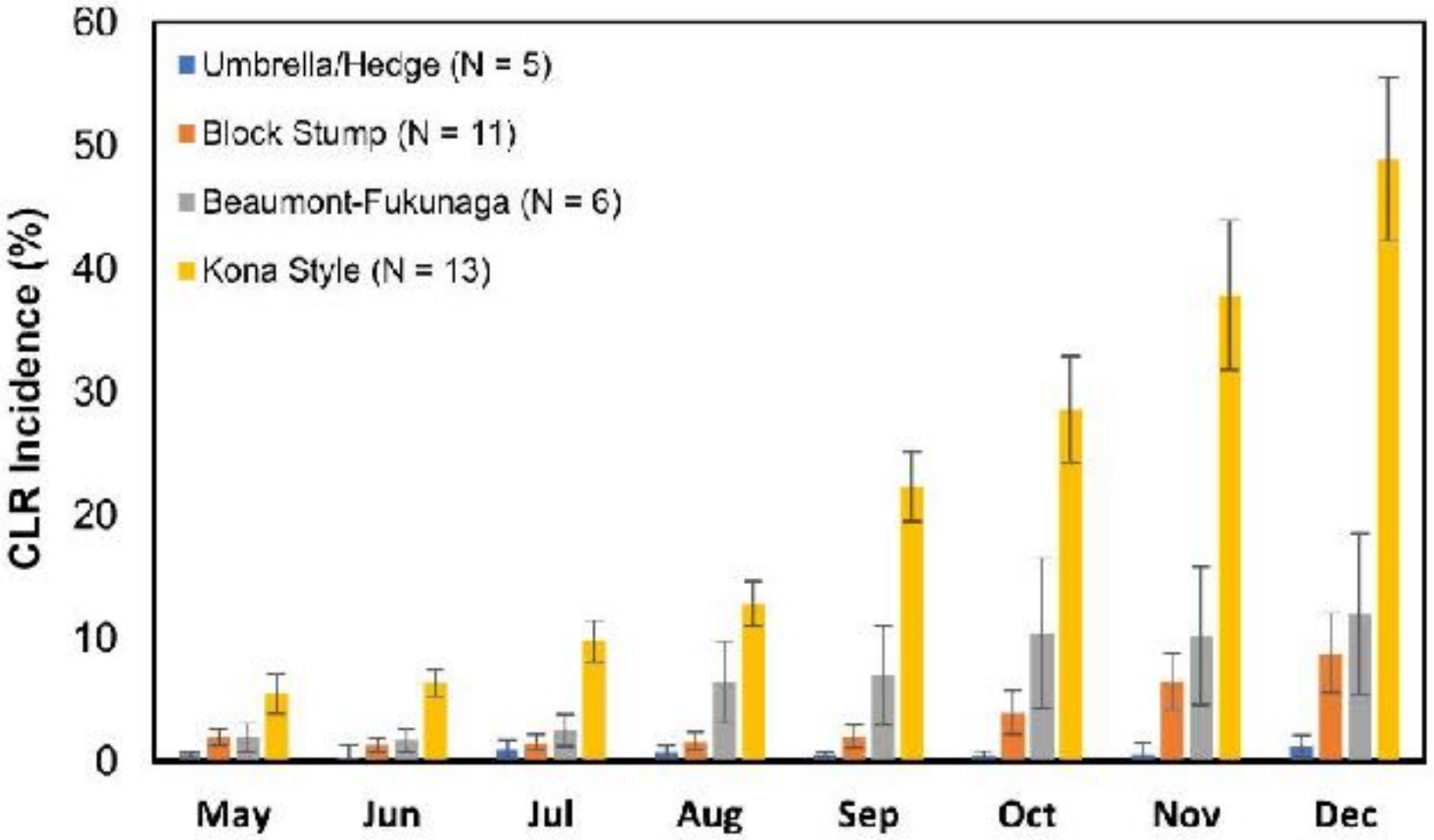
Impact on yields: Kona estimates varied from 25-70% loss for 2022

# Wind Dispersal of Spores


- Passive and active samplers set up across 15 farms in Kona, Ka'u and Hilo
- Spores captured year-round
- Spore capture coincides with CLR incidence on farms

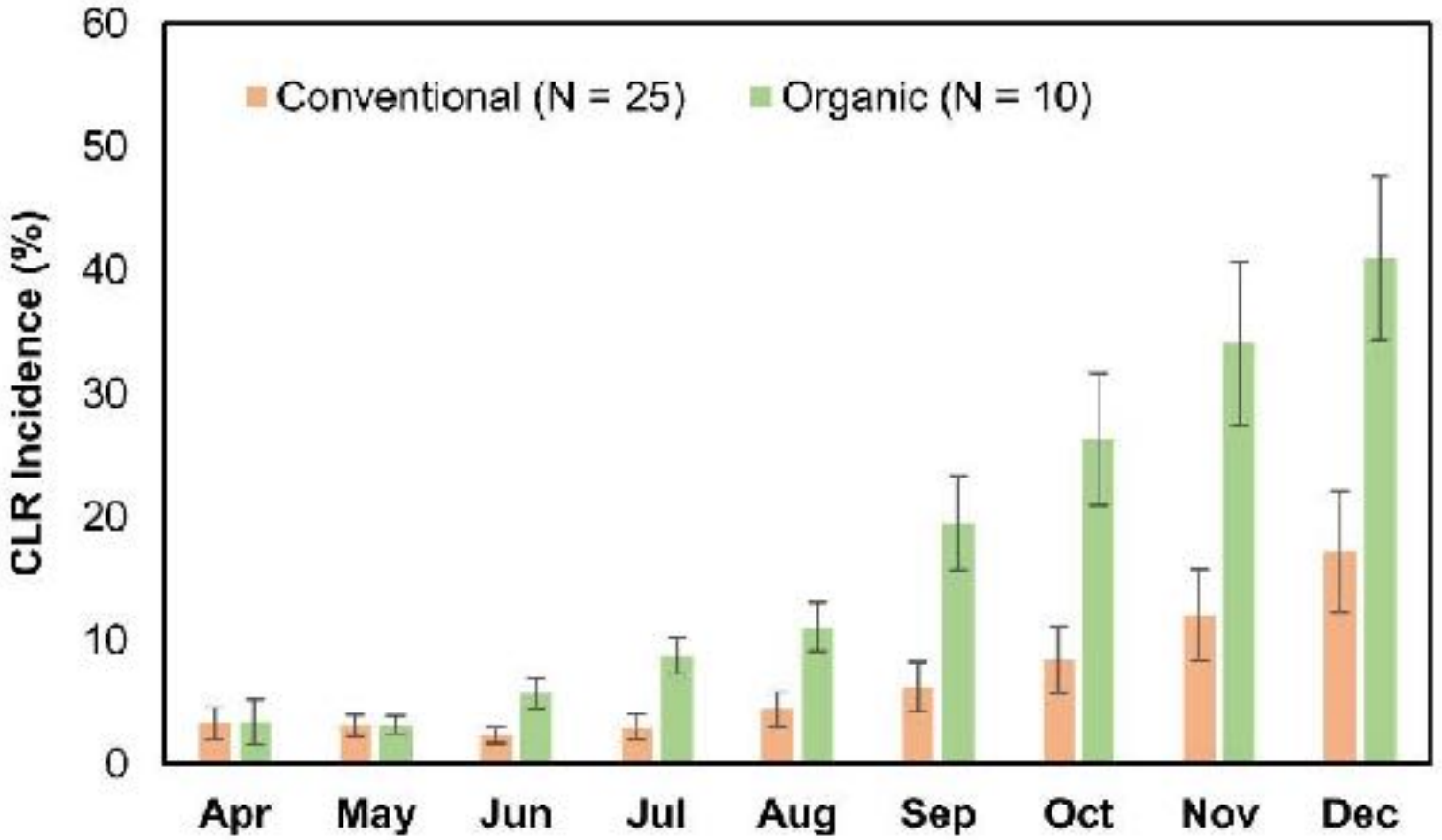
# Pruning Style & CLR incidence





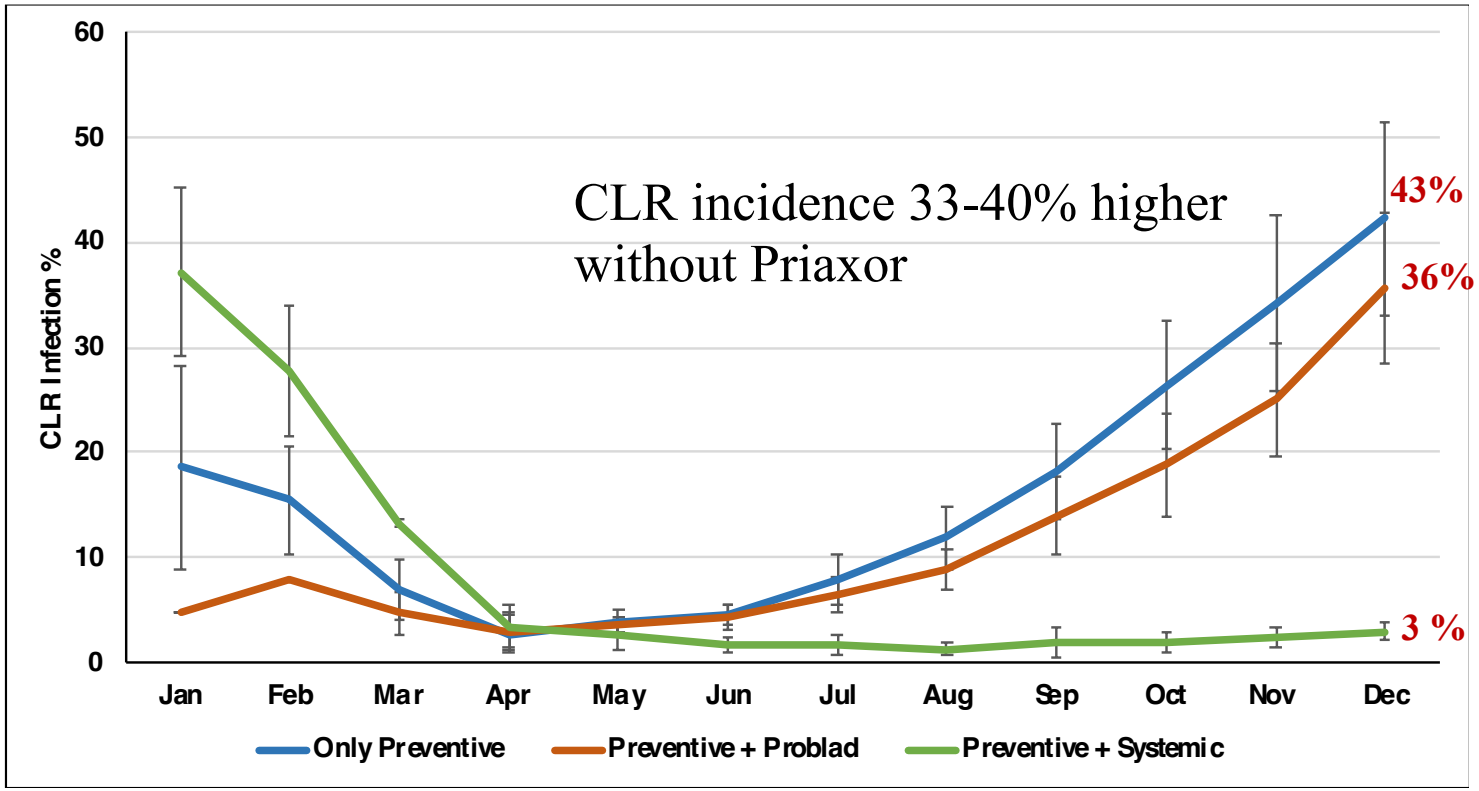


# Management & CLR incidence





# Fungicide Spray Strategies





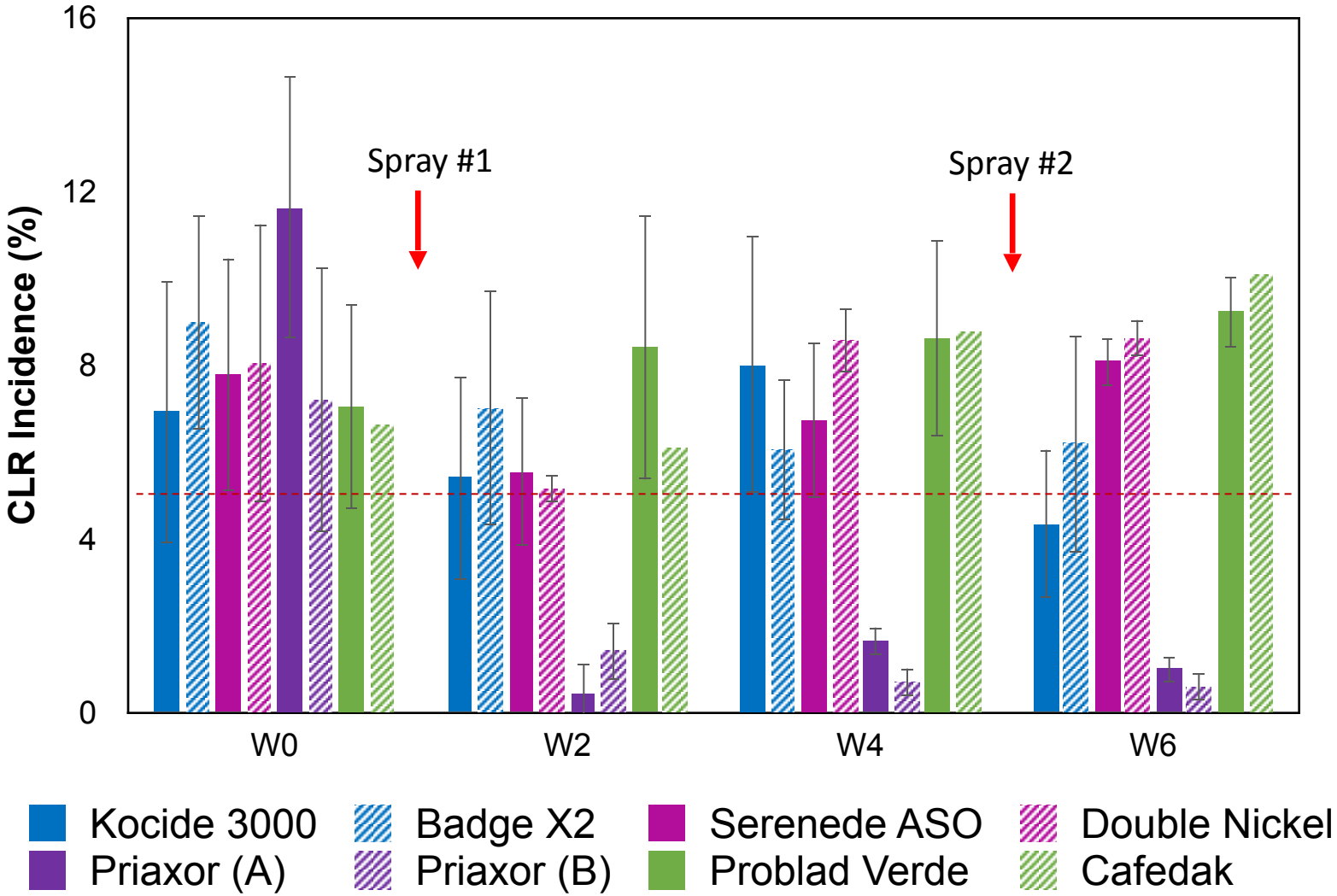

**Sprays of fungicides:** Average across 30 farms

**Only Preventive = 8 farms**

**Preventive + Problad = 9 farms**

**Preventive + Priaxor = 13 farms**

# 2023 Fungicide Trial Results (5 farm avg)



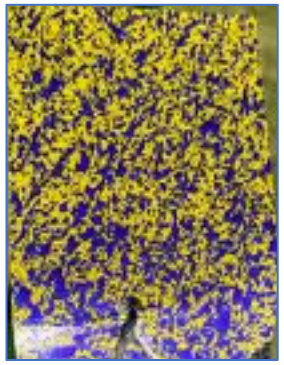

Contact:
**Luis Aristizabal**
luisaris@hawaii.edu

# Fungicide Trial Results & Rotation Program

| Week | | Farm 1 | Farm 2 | Farm 3 | Farm 4 | Farm 5 |
|---|---|---|---|---|---|---|
| | Product | Pear Tree | Cloud Rest | Captain Cook | South Kona | Hilo |
| 6 | Kocide 3000 | 1.43* | 3.66* | 1.29* | 3.65* | 11.64* |
| 6 | Badge X2 | 3.36 | 3.88 | 1.99 | 4.39 | 17.30 |
| 6 | Serenede ASO | 6.95* | 6.27* | 9.37 | 8.47* | 9.33 |
| 6 | Double Nickel | 9.73 | 12.33 | 4.74* | 9.62 | 6.72* |
| 6 | Priaxor (A) | 2.46 | 0.00 | 0.97 | NA | 0.54* |
| 6 | Priaxor (B) | 1.64* | 0.00 | 0* | NA | 0.71 |
| 6 | Problad Verde | 9.92 | 8.16 | 6.58 | 9.47* | 12.00 |
| 6 | Cafedak | NA | NA | NA | 10.06 | NA |
| | **Rotation Program** | Priaxor<br>Kocide<br>Serenade | Priaxor<br>Kocide<br>Serenade | Priaxor<br>Kocide<br>Double Nickel | Kocide<br>Serenade<br>Problad | Priaxor<br>Double Nickel<br>Kocide |

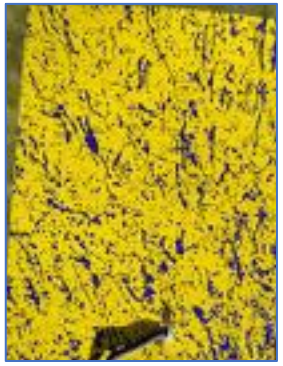
# Drone spraying: fungicides, pesticides, fertilizers

AG-110, 2.6 gal tank, 20 ft swath, 15 ac/hr



60%

40%



20%

- Testing parameters
  - Spray altitude
  - Speed
  - Flow rate
  - Coverage
  - Drift

- Hotspot and row sprays
- Economic comparison between drone spraying and backpack/tractor sprayers
  - Time
  - Labor
  - Product amount

# Artificial Intelligence for Better Farming

- Funded by the ARS AI Innovation Fund (FY23)
- High-fidelity machine vision model
  - Pests
  - Diseases
  - Nutrient deficiencies

- Field use focused
  - Optimized results and recommendations for growers
  - Will be easily accessed via mobile app

- Responsive data collection and analysis
  - Validation and improvement by climate, soil data and more TBA

Wanna Learn More?

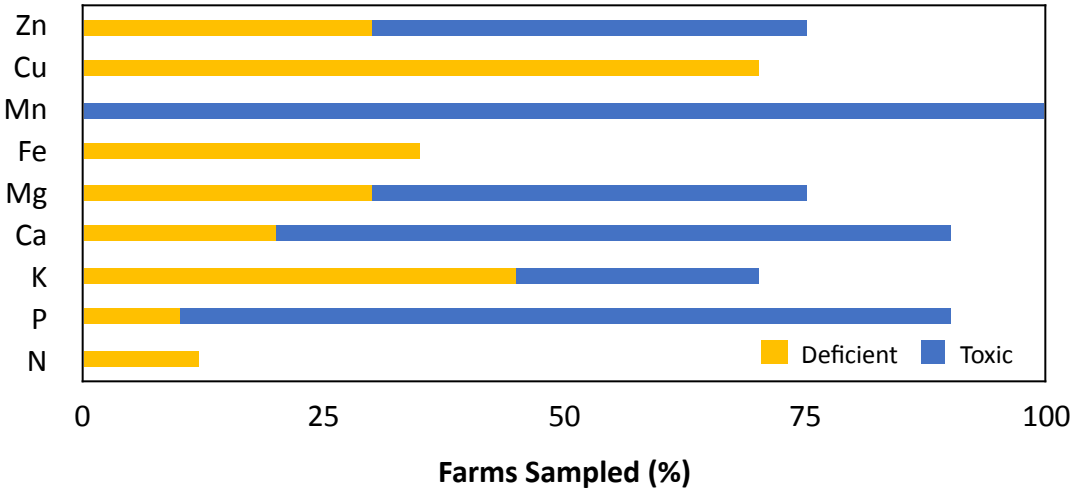
SCAN ME

Contact:
**Vincent Kimura**
vincent.kimura@smartyields.com

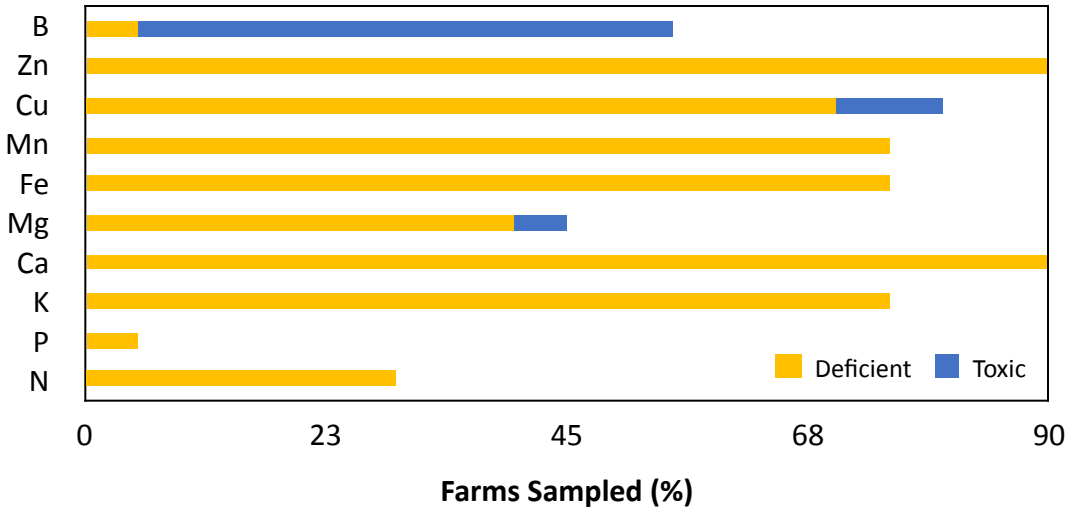
**SMART** YIELDS

# Survey of coffee soils and plant nutrition

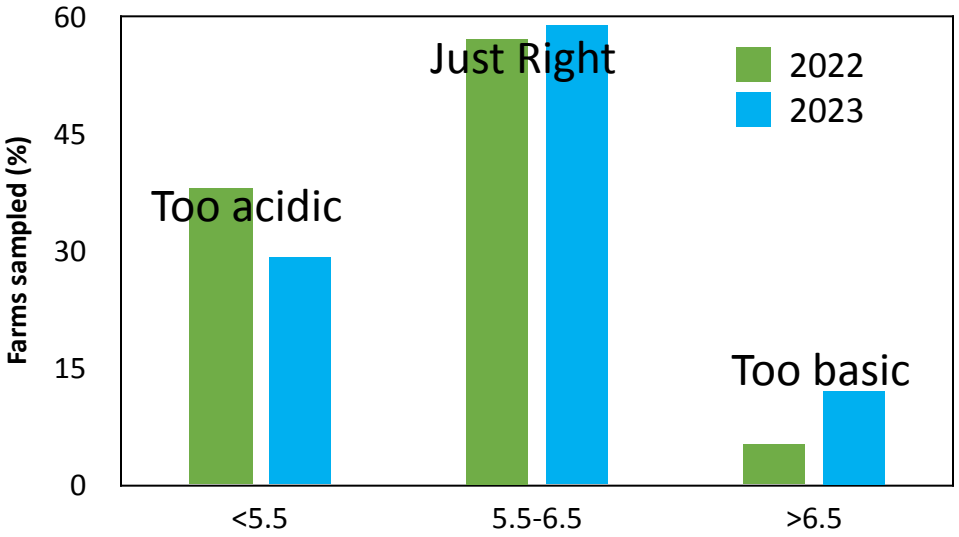
## Soil

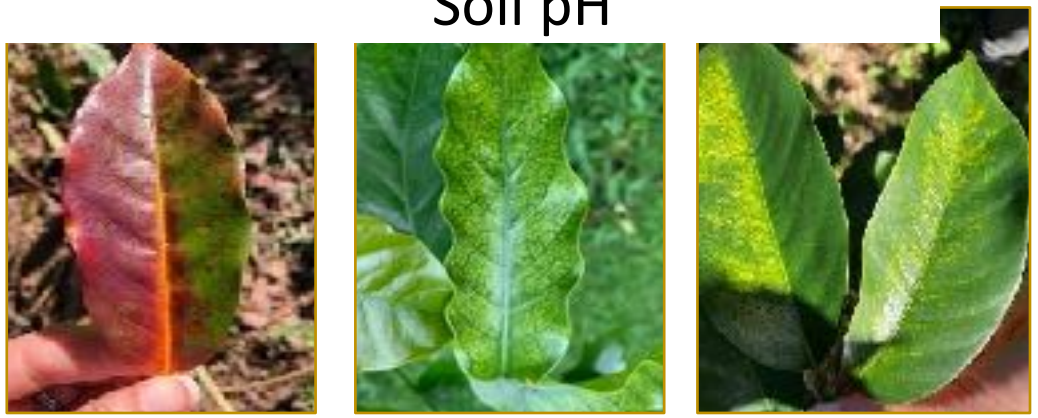



## Leaf Tissue




## Soil pH



# Optimizing soil & plant health

ORGANIC FARMING RESEARCH FOUNDATION

Grower-led initiative focused on optimizing soil and plant health to fight CLR instead of relying on chemical fungicides

Emphasis on locally sourced inputs: fertilizer made from fish waste, indigenous microorganisms (IMOs) made on the farm with simple and cheap ingredients

Continued use of imported fertilizers not economically or environmentally sustainable

Ongoing study funded by OFRF, CTAHR and PBARC, additional funding sought through SARE grant

Contact:
**Colehour Bondera**
colemel2@gmail.com

# Acknowledgements


- MAHALO to the all the coffee growers for your continued support and cooperation.

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Anwar Ali-Ahmad
Everette Ganir
Luis Aristizábal

CLR Monitoring:
Luis Aristizábal
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Jared Nishimoto
Karma Kissinger
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Karma Kissinger
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Kathy Vass
Krista Olsen

Plant/Soil Surveys:
Suzanne Shriner
Colby Maeda
Jared Nishimoto
Karma Kissinger

Drone Spraying:
Jason Dzurisin
Jared Nishimoto
Colby Maeda



USDA ARS
United States Department of Agriculture
Agricultural Research Service



Contact: melissa.johnson@usda.gov

# Managing Coffee Leaf Rust: A Research Update

Dr. Lisa Keith; HCA 2023

- Fungicide/Product Testing
- Variety Testing
- Natural Enemies


Lionel Sugiyama


Blaine Luiz


Katelin Branco


Madison Carvalho


Melissa Eyre


MaryAnn Villalun

## Teamwork!

Growers & Producers

Dr. Tracie Matsumoto Lab
Dr. Roxana Myers Lab
Dr. Qingyi Yu Lab
Dr. Melissa Johnson Lab
PBARC Germplasm Crew

Andrea Kawabata
HARC
UHM IR-4
SHAC

And Many Others



USDA Agricultural Research Service

# Product testing

## Vapor Gard® & Not Nice to Bugs

- Purpose: To protect seedlings against CLR infection


- Methods
  - Prepare product according to label
  - Spray Typica seedlings
  - Inoculate the three youngest nodes with fully expanded mature leaves (six leaves total per plant)
  - Observe plants weekly for 8 weeks
  - Record incidence and severity data



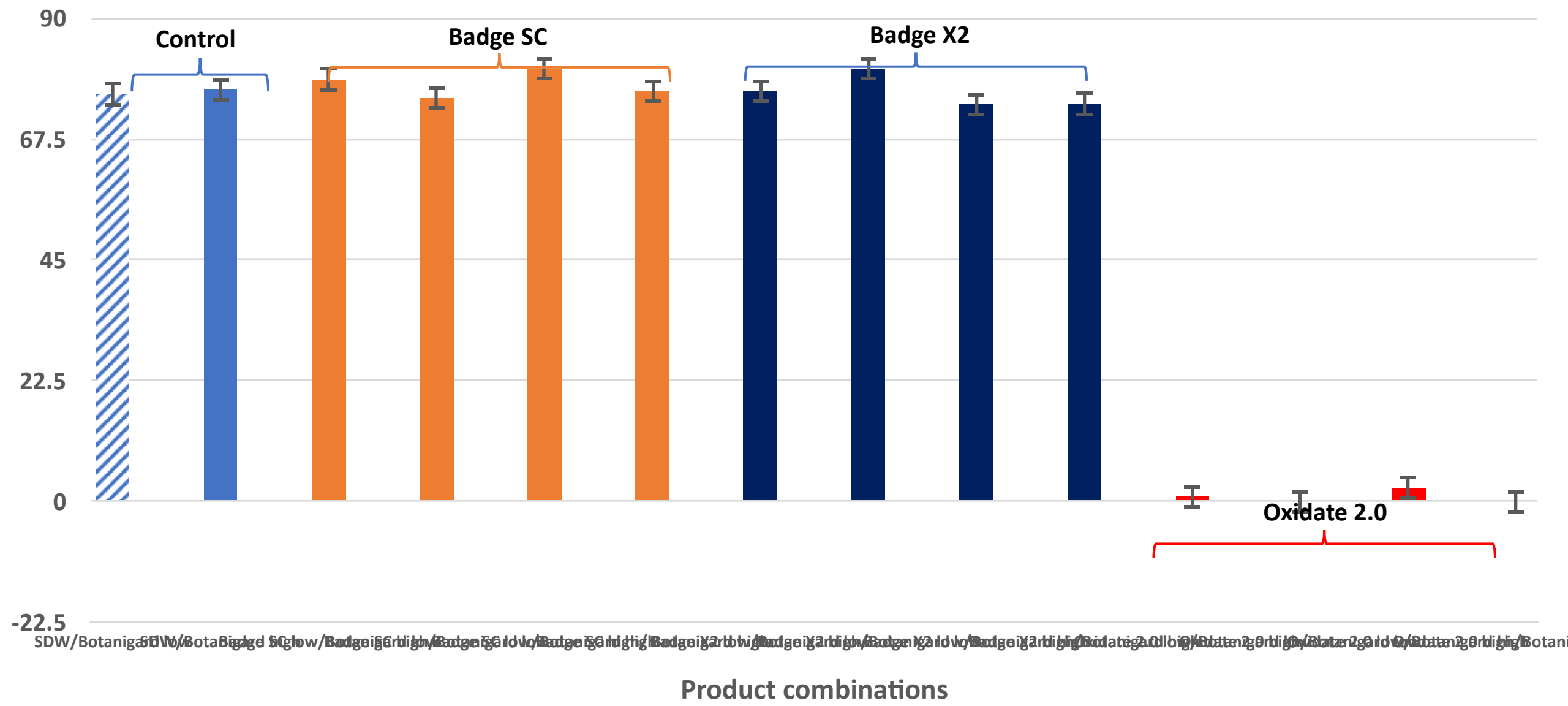
Photo: Blaine Luiz

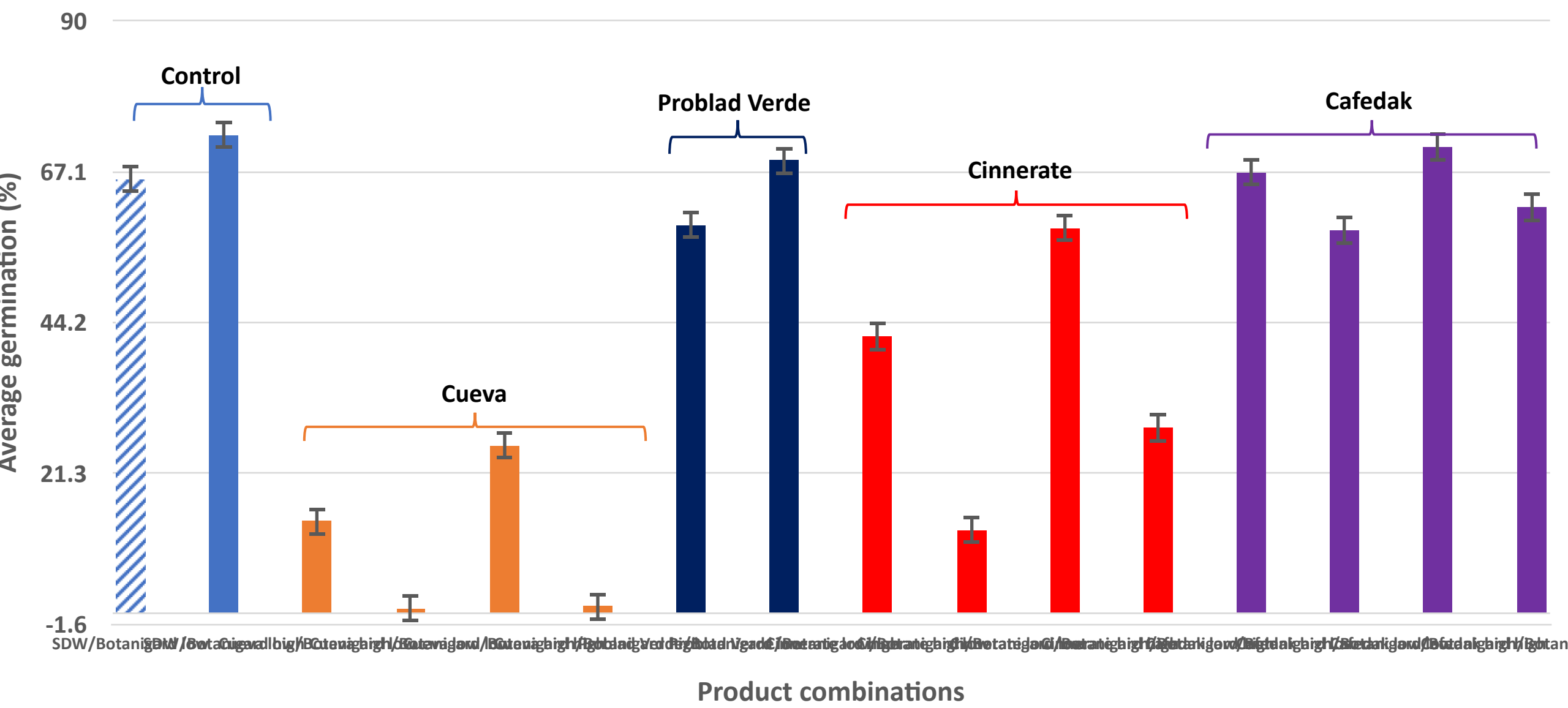

Water
Vapor Gard®
low rate
Vapor Gard®
high rate
Not Nice
to Bugs
fungicide
No CIS or urediniospore production
Photos: Blaine Luiz
USDA Agricultural Research Service

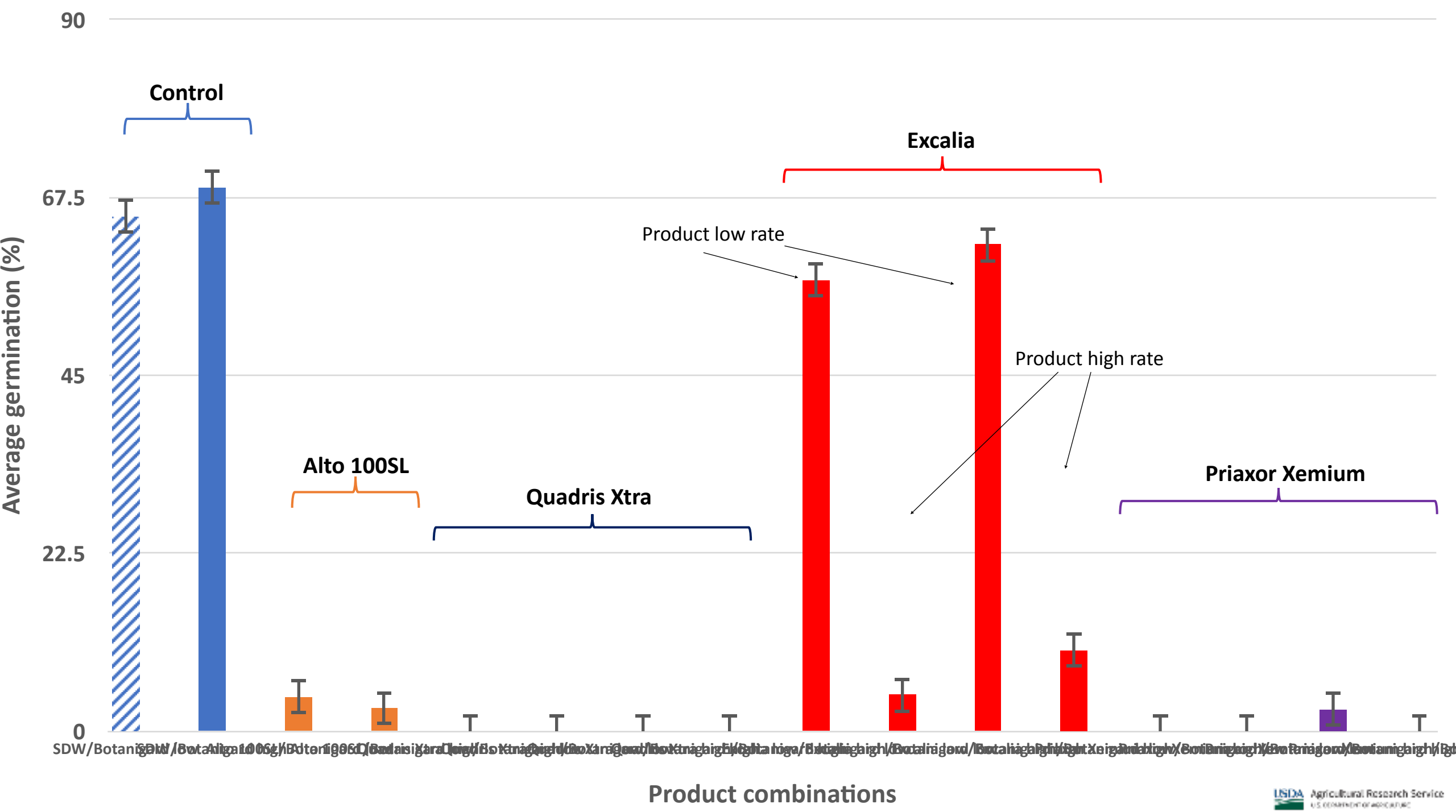
# Tank Mixing

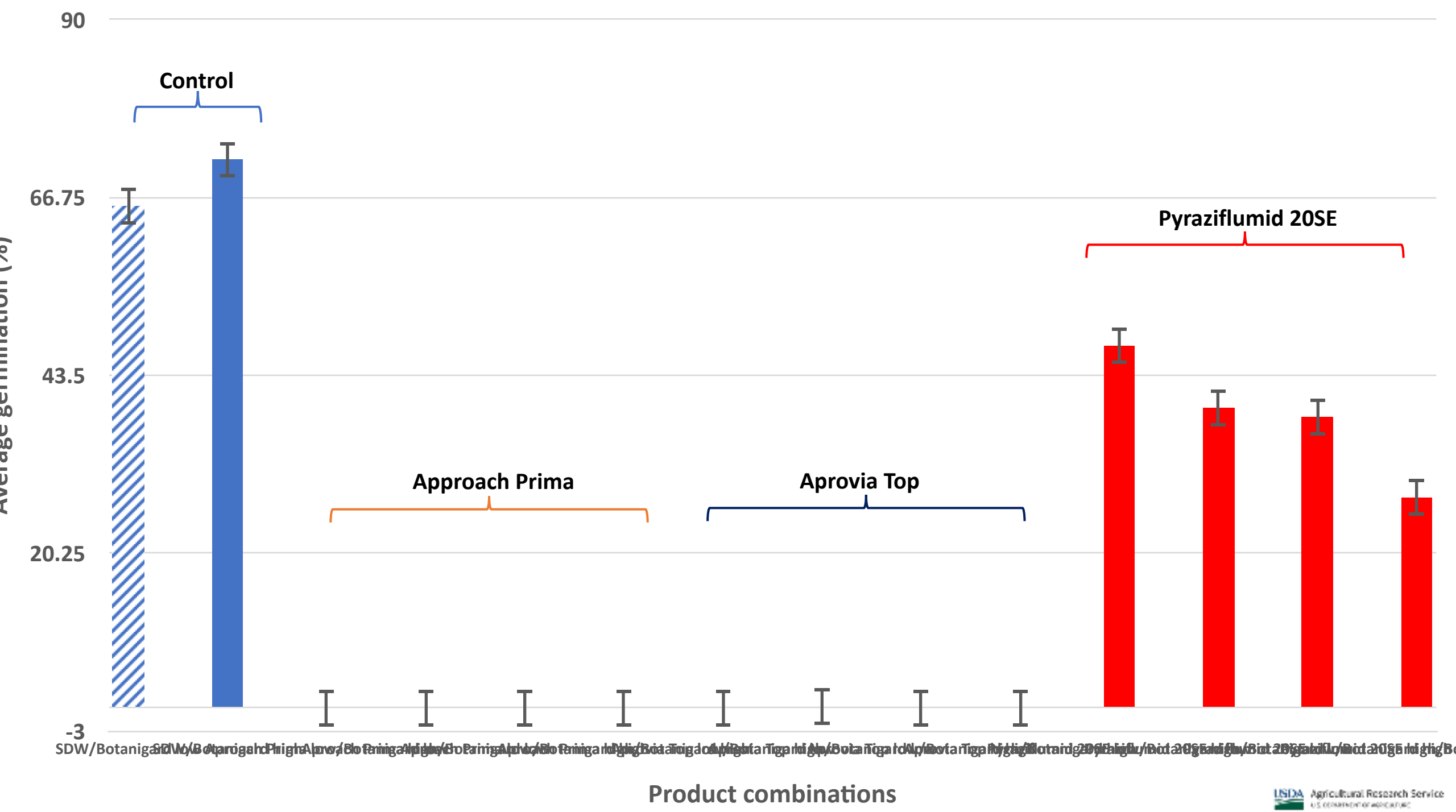
## BotaniGard x CLR protectants/fungicides

- Purpose: To verify compatibility
- Method:
  - Prepare mixes at 2x concentration of BotaniGard and test products at both the low and high rates
  - Mix BotaniGard and test product
  - Agitate for 60 sec
  - Plate solution, spread, and dry
  - Incubate 16-17 hours at 25C
  - Stain with cotton blue
  - Record germination status



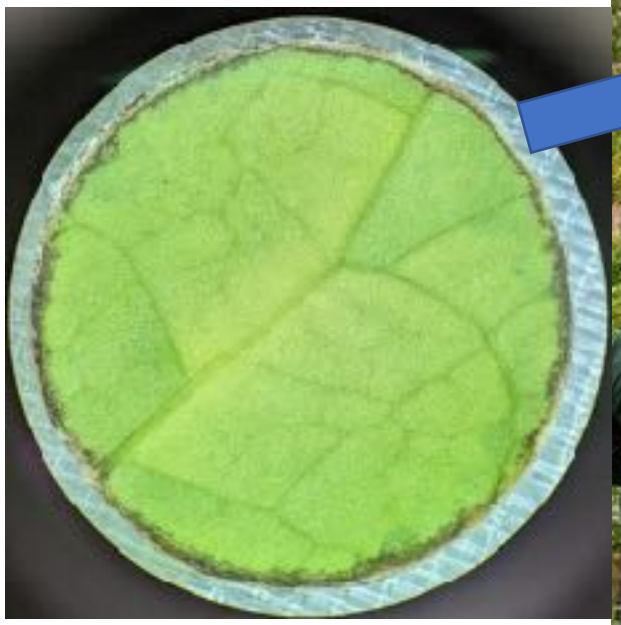



90
67.5
45
22.5
0
Average germination (%)
Control
Alto 100SL
Quadris Xtra
Excalia
Product low rate
Product high rate
Priaxor Xemium
Product combinations
USDA Agricultural Research Service

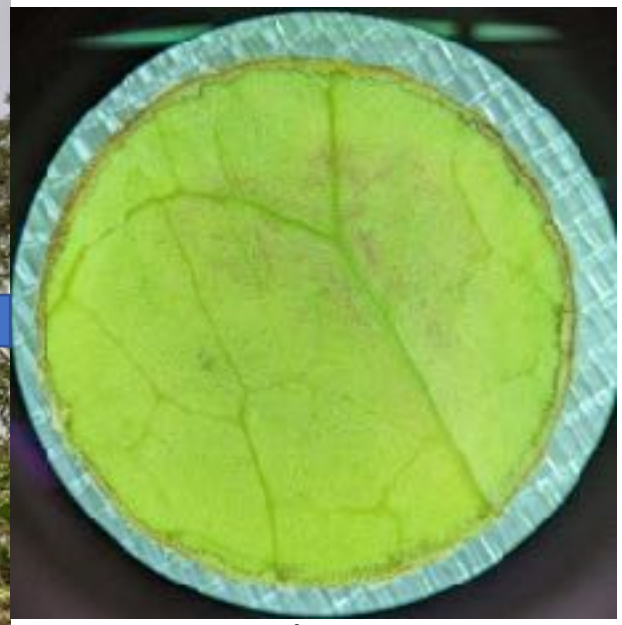

90
66.75
43.5
20.25
-3
Average germination (%)
Control
Approach Prima
Aprovia Top
Pyraziflumid 20SE
Product combinations
USDA Agricultural Research Service

# Novel CLR-resistant genotypes on an established farm

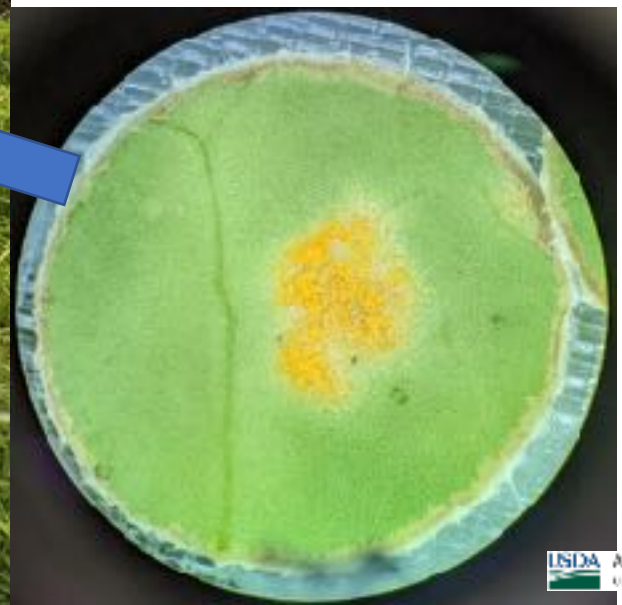
# Variety Testing



Resistant



Resistant



Susceptible Typica/ Bourbon

Photos: Blaine Luiz

# UH CTAHR Kona Extension Catimor crosses

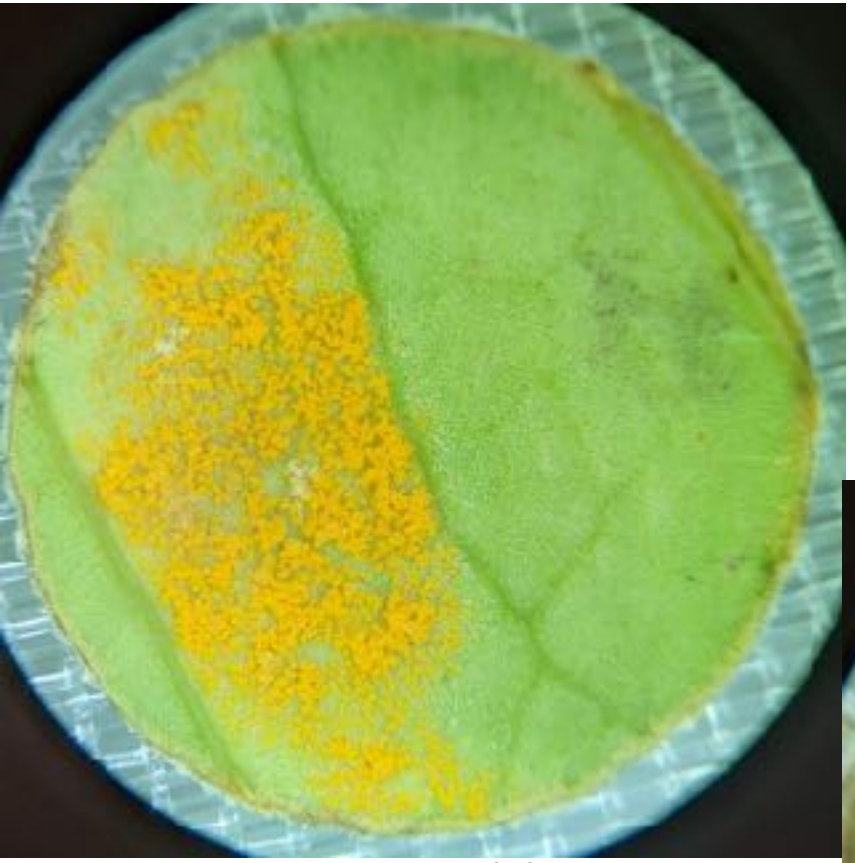
Susceptible control

## Resistant hybrid genotype

- Resistant genotypes tested from UH CTAHR Kainaliu Station do not experience CLR infection symptoms in the field.
- Observational data collected over two seasons by station staff

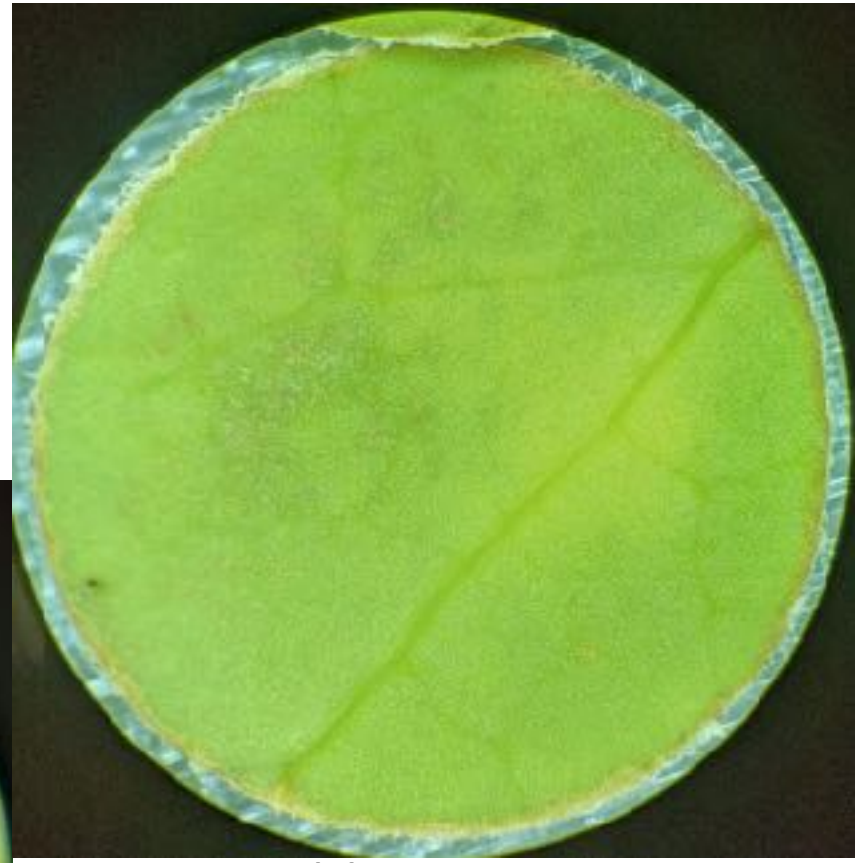
Photos: Blaine Luiz

# HARC CLR resistance breeding



Susceptible

Intermediate resistance



Highly resistant

Photos: Blaine Luiz

# Summary of Results

- Leaf disk bioassay results: highly susceptible to highly resistant
- Results generally correlate to field observations
  - Highly susceptible genotypes in the leaf disk bioassay show high incidence and severity in field conditions under high inoculum pressure
  - Resistant genotypes are showing low levels or no infection in the field, even when nearby susceptible trees have high disease incidence and severity

# Natural Enemies of CLR: Mycoparasite Survey

- Over 600 lesions sampled
- 194 isolates recovered → 50 unique taxa identified
- Notable taxa: *Simplicillium, Akanthomyces, Clonostachys, Pleurodesmospora, Fusarium, Cladosporium*
- Next steps: Lab
  - Inhibition of CLR spore germinatio
  - Pre/Post-CLR infection control
  - Combinations of fungi
  - Plant safety
- Future steps: Field
  - Efficacy under field conditions
  - Establishment of fungi in leaf tissues
  - Longevity of fungi in tissues in relation to fungicide applications

Photos: Blaine Luiz

Upper surface

Lower surface*

Good Spray Coverage is Key

Lisa.Keith@USDA.GOV

USDA Agricultural Research Service

# Coffee Varieties for Hawaii

Tracie Matsumoto
Supervisory Research Horticulturist

# Overview

**Medium Term ~1-2 years**

- Local CLR resistant Varieties
- World Coffee Research International Multilocation Variety Trial
- Importation of Commercial Varieties through Controlled Import Permit

**Longer Term ~3-5+ years**

- Breeding New Varieties

# Importation of Coffee from International Sources are Prohibited into Hawaii or Puerto Rico

## Coffee (Roasted, Green, Whole, Seeds, Plant Parts)

USDA's requirements for the entry of coffee/coffee beans carried by a traveler differ according to the specific form of the product and location of the port of entry:

- **Roasted Coffee**: Travelers are permitted to bring unlimited quantities of roasted coffee in their luggage without restriction through any U.S. port of entry. However, as with all agricultural products, you must declare the product at entry.
- **Green (unroasted) Coffee Beans**: Travelers are permitted to bring unlimited quantities of green coffee beans in their luggage without restriction through any port of entry in the continental United States; however, green coffee beans are prohibited from entering into or transiting through Hawaii or Puerto Rico. As with all agricultural products, you must declare the product at entry. If any quarantine pests are found in green coffee beans, the product will be seized and destroyed.
- **Whole Coffee Berries** (aka, coffee cherries): fresh coffee berries—defined as the unprocessed, whole coffee fruit with pulp—**are prohibited entry at all U.S. ports of entry** because the pulp presents an exotic fruit-fly risk.

**Coffee Seeds or Other Plant Parts** intended for planting **are prohibited entry into Hawaii or Puerto Rico.** Additionally, some varieties are protected as threatened or endangered species and have specific restrictions because of their status.

https://www.aphis.usda.gov/aphis/resources/traveler/intl-travel/coffee-tea-honey-nuts-spices/coffee-tea-honey-nuts-spices

**Coffee must be brought in through a Controlled Import Permit through USDA APHIS**

# Importation of Coffee Plants and Seeds for propagation requires quarantine

State of Hawaii
**Plant Industry Division**

HDOA | Plant Industry Division | Plant Quarantine Branch | Plant Pest Control Branch

Home » Plant Quarantine Branch » Import Program » Plant Guidelines

## PLANT GUIDELINES

General guidelines for the importation of plants to Hawaii are as follows:

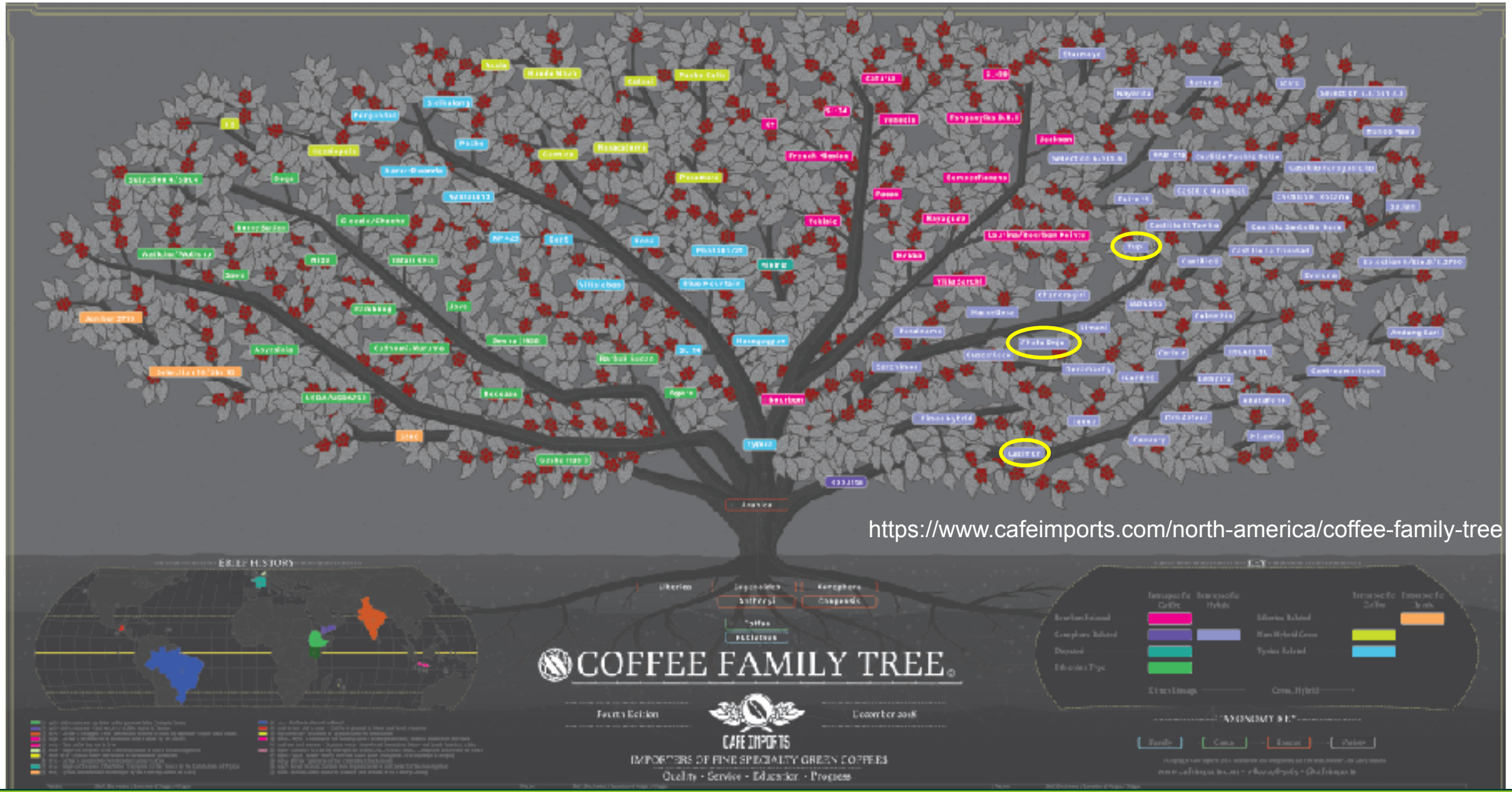
- All plants require inspection upon entry into the state.
- Plants must be apparently free of insects and diseases.
- Plants do not need to be bare-rooted but the growing media cannot contain soil.
- Parcels brought into the state by mail or cargo must be clearly labeled with the words "Plant Materials" or "Agricultural Commodities".
- Shipments must be accompanied with an invoice or packing manifest listing the contents and quantities of the commodities imported.

The following items require permits, and/or certificates of origin or treatment. Some are subject to a holding period in a quarantine facility.

Information on obtaining Plant Quarantine import permits.

- **Grass family (sugarcane, bamboo, and grass):** Plants and parts require permit and quarantine. Seeds and dried parts of bamboo and grass are unrestricted.
- **Bromeliad family (pineapple, bromeliads, and tillandsia):** Plants and parts require a permit and a certificate of origin and/or treatment. Some plants require quarantine. Seeds and flasks of bromeliads (except pineapple) are unrestricted.
- **Coffee:** Plants, plant parts, and used coffee bags require permit and certificate of treatment. Plants and seeds for propagation also require quarantine.
- **Cruciferous vegetables:** The edible roots of turnip, rutabaga, radish (daikon), and horseradish require certificate of origin or certificate of treatment depending upon where they are grown.
- **Orchid family:** Plants and propagative parts require permit and certificate of origin. Some plants require quarantine. Seeds and deflasked tissue culture plants are unrestricted.

https://hdoa.hawaii.gov/pi/pq/import-program/plant-guidelines/




https://www.cafeimports.com/north-america/coffee-family-tree

# Local CLR resistant cultivars

# Genetic Characterization of Coffee Germplasm, Dr. Dapeng Zhang, ARS Beltsville

A SNP is a single base change in a DNA sequence that occurs in a significant degree (>1%) within a population

```
ACGTGAATTCACTAG
ACGTGAATTCACTAG
ACGTGAACTCACTAG
ACGTGAATTCACTAG
ACGTGAACTCACTAG
ACGTGAATTCACTAG
```

Select a small SNP panel for genotyping Arabica coffee

132 accessions from CATIE International Coffee Collection

1) Typica/Bourbon
2) East African varieties
3) Ethiopian landraces and wild germplasm
4) Introgressed varieties
5) C. canephora

Zhang et al, ASIC 28th Conference 2021

Merot-L'Anthoene et al., 2019. Development and evaluation of a genome-wide coffee 8.5K SNP array and its application for high-density genetic mapping and for investigating the origin of Coffea arabica L. Plant Biotechnol J. 17:1418–1430.

# Identification and Propagation of CLR tolerant varieties in farmer fields

Mike Shintaku's lab
Propagation of plants through somatic embryogenesis

Juan

Cruz

Maite

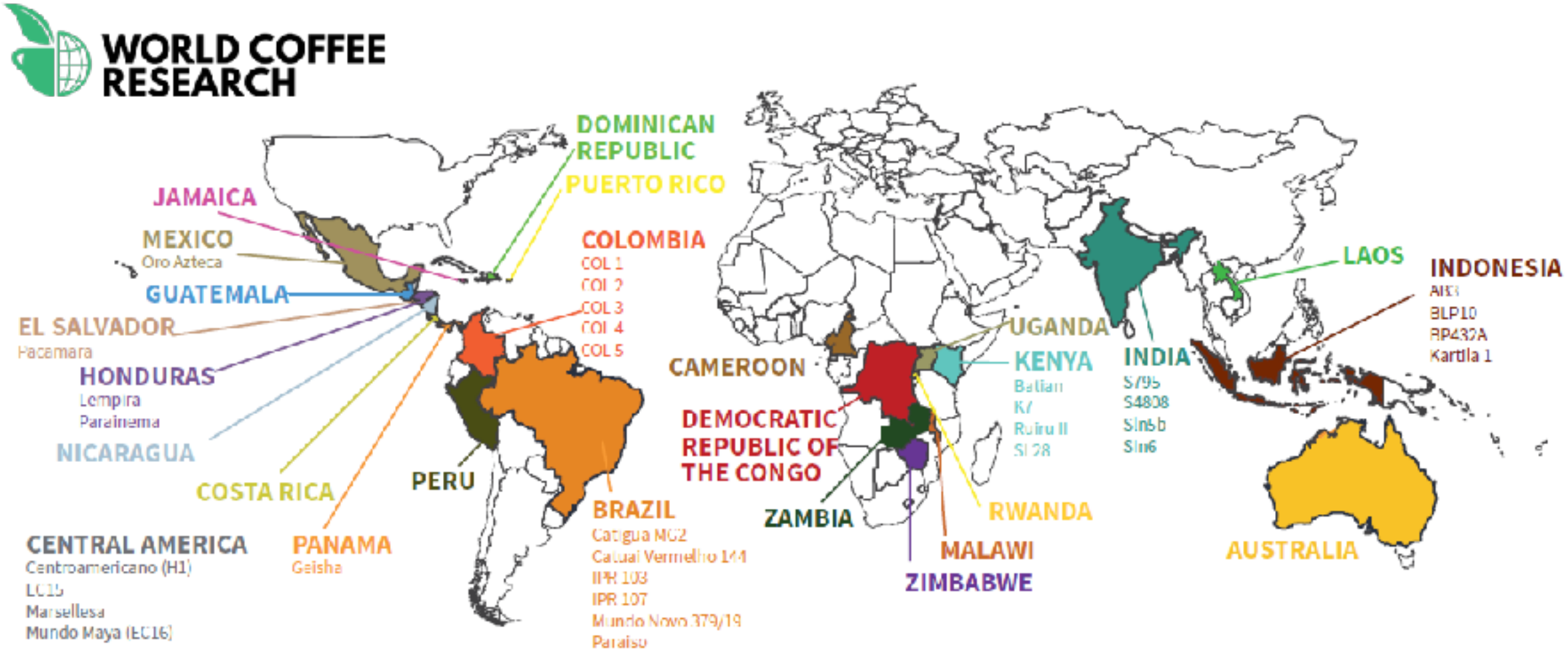
| Name | Ethiopia | Bourbon | Typica | SL28 SL34 | Catuai | Catimor | Sarchimor | Inferred Parentage |
|---|---|---|---|---|---|---|---|---|
| Juan | 0.711 | 0.001 | 0.003 | 0.002 | 0.001 | 0.018 | 0.263 | Ethiopia_Sarchimor |
| Cruz | 0.635 | 0.002 | 0.001 | 0.003 | 0.001 | 0.062 | 0.296 | Ethiopia_Sarchimor |
| Maite | 0.368 | 0.316 | 0.001 | 0.006 | 0.002 | 0.010 | 0.297 | Ethiopia_Sarchimor_Bourbon |

# Background

Dr. Chifumi Nagai, Plant Breeder, HARC

- Until October 2020, Hawaii was the only major coffee-producing region without Coffee Leaf Rust
- Dr. Nagai started breeding for CLR resistance in Hawaii
- Collaboration with Dr. Vítor Várzea facilitated CLR identification in Hawaii is Race XXIV
- In 2017, in collaboration with Dr. Nagai, Hawaii became a participant in International Multilocation Variety Trial

# World Coffee Research
# International Multilocation Variety Trial



# IMLVT Coffee Varieties in Tissue Culture

**Susceptible***

- AB3
- BLP10
- Catuai V IAC144
- Geisha
- K7
- Lempira
- Mundo Novo 379/19
- Pacamara
- SL28
- Typica

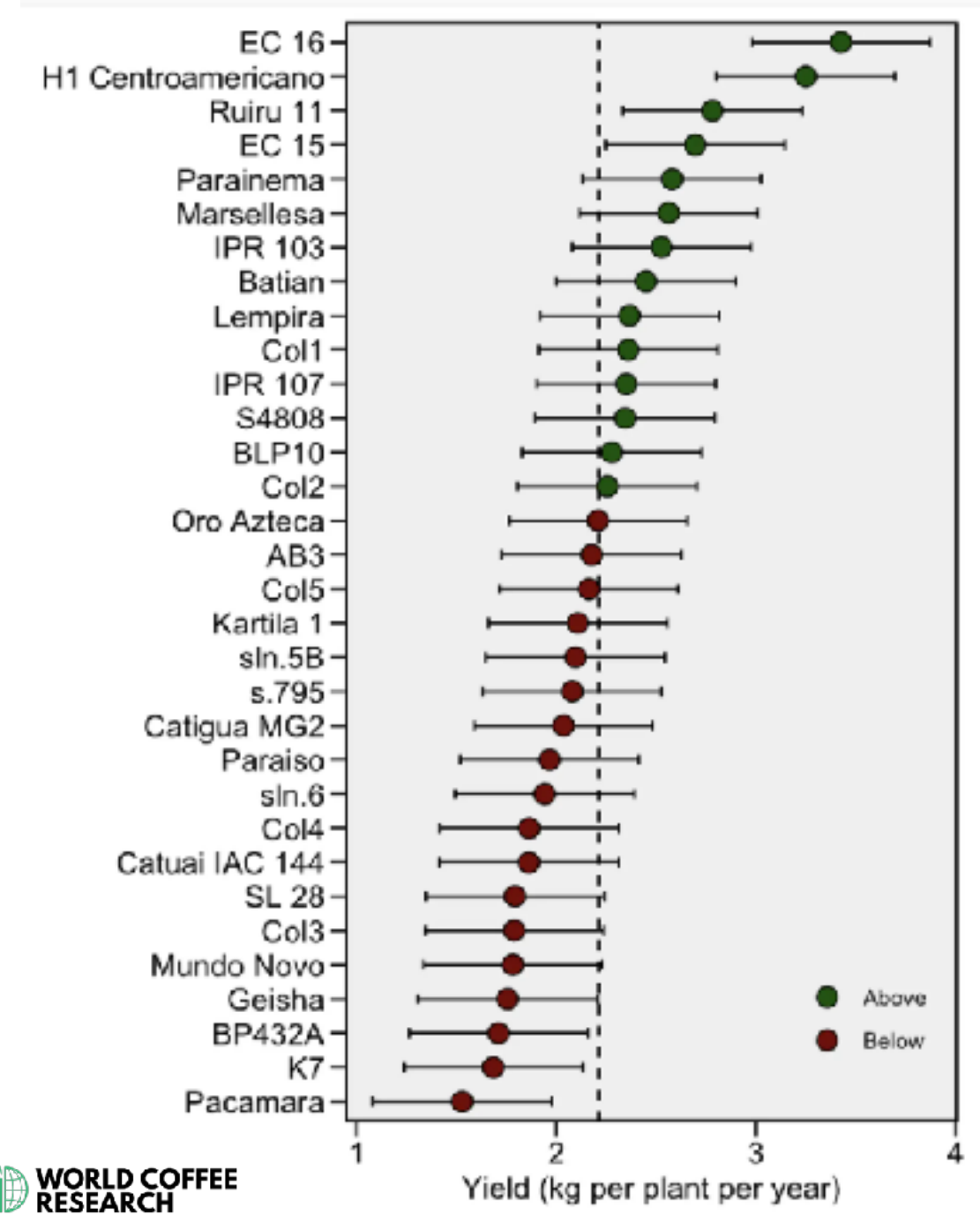
**Tolerant/Resistant***

- Batian
- Catigua MG2
- Col1
- Col2
- Col3
- Col4
- EC15
- EC16
- Centroamericano H1
- IPR103
- IPR107
- Kartila 1
- Marsellesa
- Oro Azteca
- Parainema

*general CLR, not necessarily Race XXIV

# Global Yield Evaluation of IMLVT Lines

- yield is site dependent
  - Temperature
  - rainfall
  - pest and diseases
- F1 hybrids (EC16 – Mundo Maya) and H1 Centroamericano perform best globally

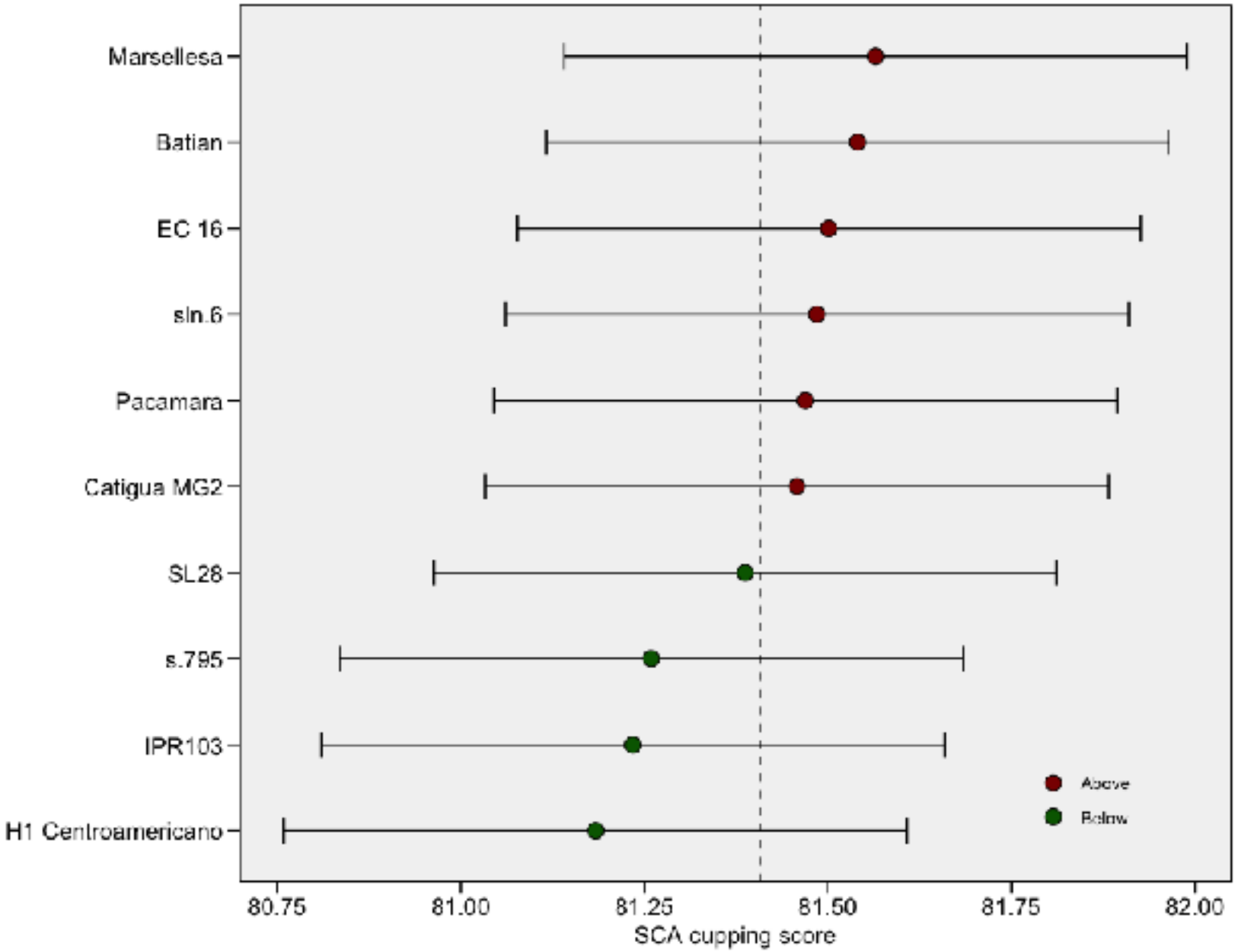



WORLD COFFEE RESEARCH

https://worldcoffeeresearch.org/news/2022/imlvt-global-results

# Global Cupping Results 2021

- 6 countries
- 10 varieties
  - Bulk of 3 blocks
- 25 Cuppers
- SCA protocol




https://worldcoffeeresearch.org/news/2022/imlvt-global-results

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# Hawaii Coffee Variety Trials


Figure 2. Fischer block trial design. Each variety is replicated three times, once in each block. The placement of the variety row is randomized across blocks.

**Data:**

- Vegetative growth (tree height and diameter, etc)
- CLR incidence and severity, other pest and disease incidence
- Flowering data (start date of flowering, date of peak flowering and date of last flowering)
- Cherry phenology data (size and maturation)
- Production data (date and weights of harvest)
- Bean quality (weight of bean, size, imperfections, and grade)
- Cupping quality

**Locations: Kauai, Oahu, Maui, and Kona**
**Compare against Typica**

**Currently working with Breeders to get rights for Hawaii growers to get varieties**


Photo credit Andrea Kawabata

# Hawaii Cupping of IMLVT Lines

WCR provided 100g of green bean bulked from different IMLVT locations

Kona coffee “control” provided by Tommy Greenwell

Roasted by Marlee Benefield from Gather Coffee

Will be cupped by local Hawaii Q-graders at PCR through Madeleine Longoria Garcia







# Other Coffee Varieties

San Francisco Bay Coffee - Andros Bracamontes & Noel Arrieta

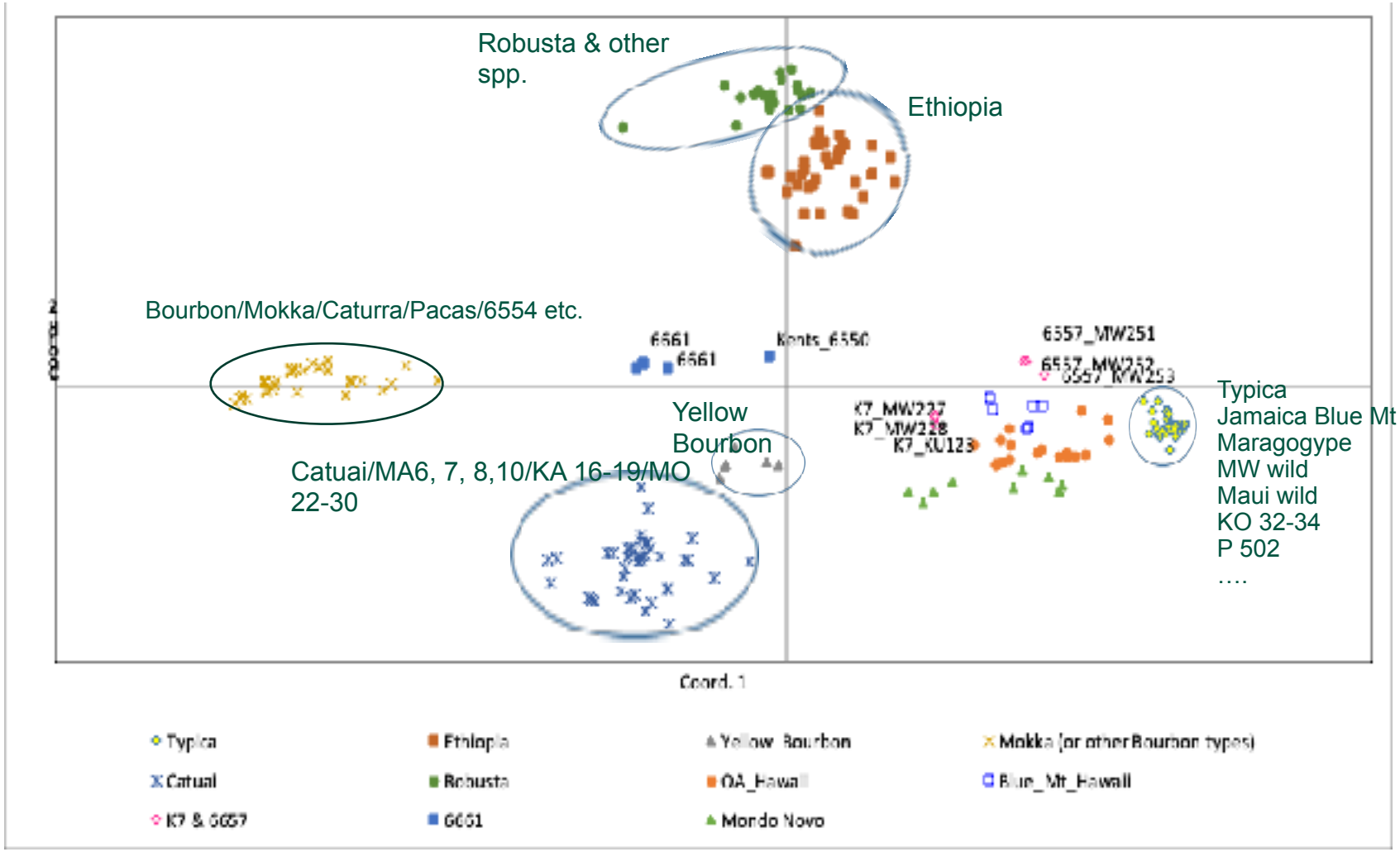
Seed import: Catigua MG2, Obata Amarillo, Obata Rojo, and Paradiso

Somatic Embryos: Casiopea, Centroamericano, Esperanza, Excelencia, Milenio


# Longer Term Projects

# Development of Molecular Marker for CLR resistance and breeding of elite Hawaiian Coffee Cultivars

Dr. Ming-Li Wang, HARC
Dr. Qingyi Yu, DKI PBARC
Dr. Lisa Keith, DKI PBARC




WORLD COFFEE RESEARCH

# Innovea Global Arabica Breeding Network

Restriction-free breeding populations with durable resistance to key pests and diseases, adaptation to growing conditions, and quality cupping through evaluation of phenotypes around the world.

# Innovea Breeding Progeny

- Crosses between coffee parents with different resistance
- Will select for varieties suitable for Hawaii
- Material developed will be IP free


# New Variety Pipeline at USDA ARS DKI PBARC

- Local Varieties
- WCR IMLVT
- HARC Elite CLR resistant Hawaiian Varieties
- Commercial Coffee Varieties
- WCR Innovea
- Nestle Breeding

Molecular Markers


Horticultural Evaluation and Multiplication

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**Coffee Strategic Plan Variety**
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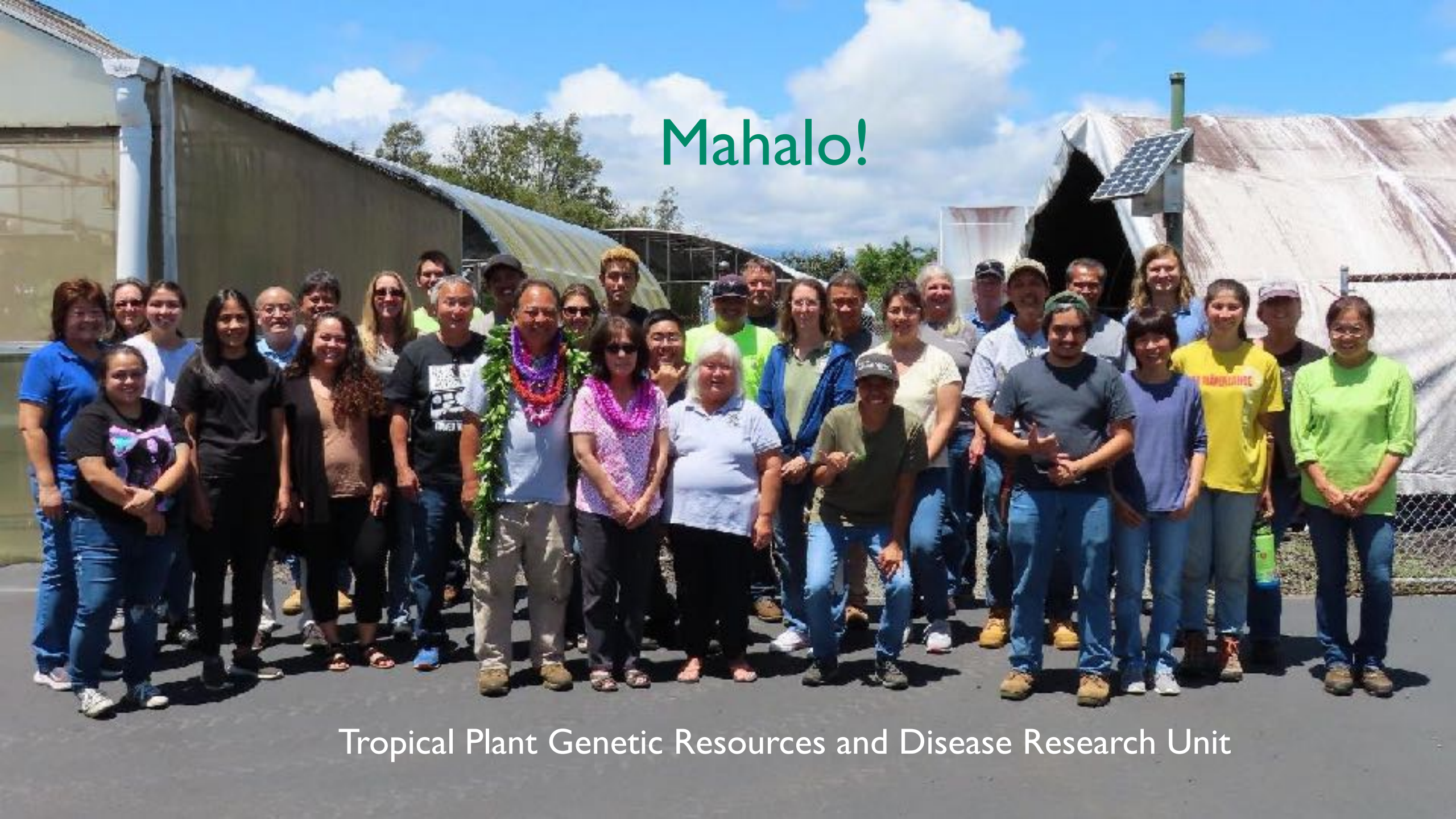
Mahalo!
Tropical Plant Genetic Resources and Disease Research Unit