Breeding for Resistance to Soilborne Pathogens in Strawberry

Mitchell J Feldmann, Steven J Knapp**,** Dominique DA Pincot, Marta L Bjornson, Peter M Henry, Christine J Dilla-Ermita, Randi A Famula, Glenn S Cole, **Allison Krill-Brown**

University of California, Davis
Department of Plant Sciences
UCD Strawberry Breeding Program

23 Annual Strawberry Production Meeting in Ventura County;
09/13/2024

UC Strawberry Breeding Program

New UCD Strawberry Breeding Team

Dr. Mitchell J. Feldmann

Director of the Strawberry Breeding Program

Allison Krill-Brown

Strawberry Breeder

Cindy Lopez

Research Associate
Trial Manager

To be hired 2025

Research Assistant
Trial Manager

UCD Strawberry Team+

Pictured: Steven Knapp, *Omar Gonzalez-Benitez*, Hillel Brukental, Glenn Cole, Mitchell Feldmann, Marco Castellacci, Jade Dilla-Ermita, Dominique Pincot, Mishi Vachev, Marta Bjornson, Alicia Sillers, Nico Jimenez, Peter Henry, Isaac Rainwater, Cindy Ramirez Lopez, Randi Famula

Not Pictured: Allison Krill-Brown, Eduardo Garcia, Nayeli Valencia, Paul Skillin, Caitlyn Morgan, Ella Halberstadt

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UC Strawberry Breeding Program

UC Strawberry Breeding Program Goal

Produce varieties with a complete disease-resistance package that are **high-yielding**, **producible** by nurseries, **shelf-stable**, **great tasting**, and **profitable** for growers.

Photo: Fresa Fortaleza

We select for **Fusarium wilt, Macrophomina charcoal rot, Verticillium wilt,** and **Phytophthora crown rot**–"the fearsome four"—resistant varieties under **extreme disease pressure.**

Intense phenotyping and modern genetic tools have greatly increased **our ability to concentrate favorable traits** and **deliver value to stakeholders.**

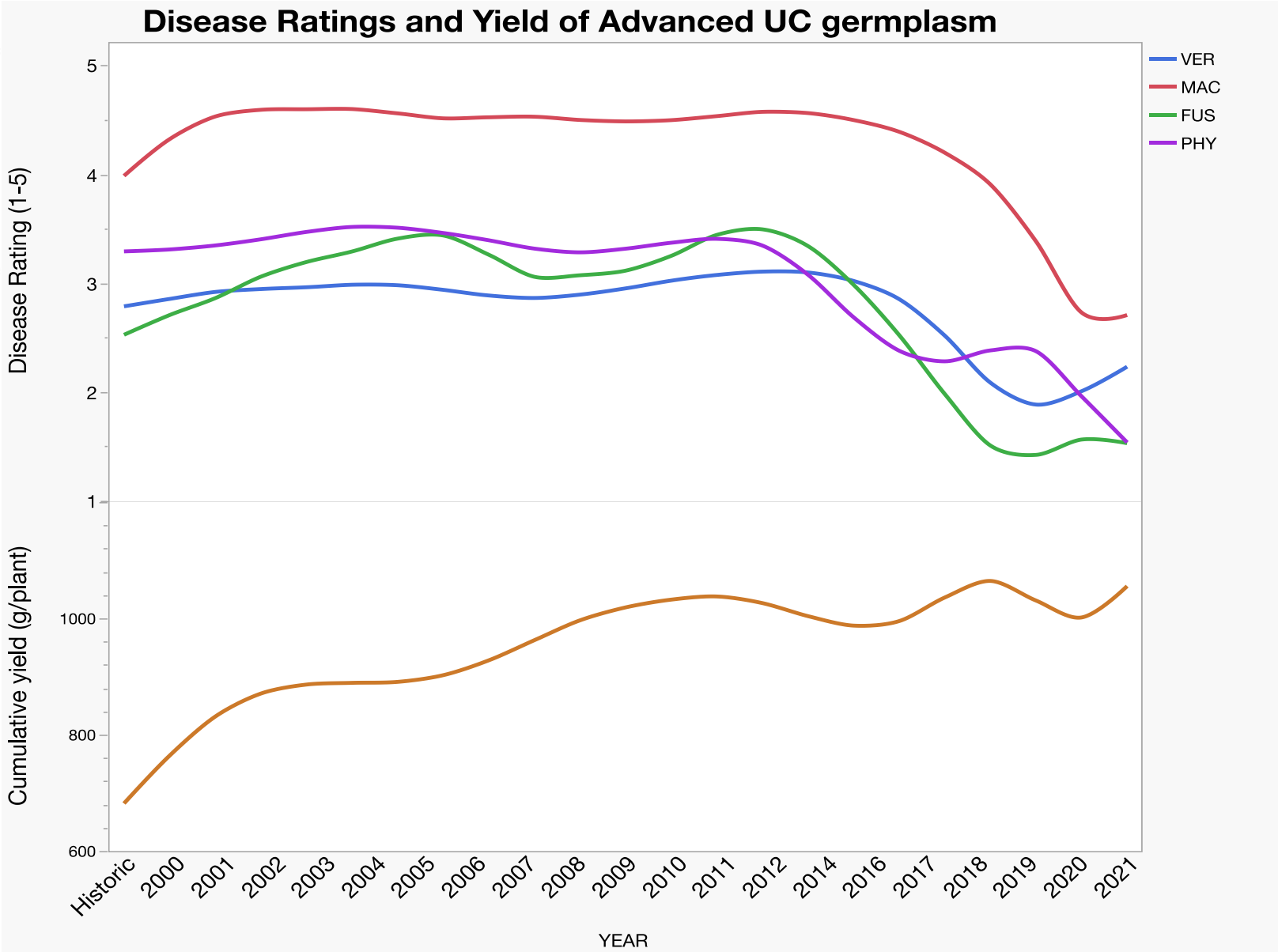
Improving disease resistance without compromising yield

Verticillium wilt resistance improved by 0.6 units (14.8%)

Fusarium wilt resistance improved by 1.5 units (37.5%)

Phytophthora crown rot resistance improved by 1.4 units. (35.8%)

Macrophomina charcoal rot resistance improved by 1.6 units (40.6%)



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Fusarium Wilt

Started studying FW (race 1) in 2015

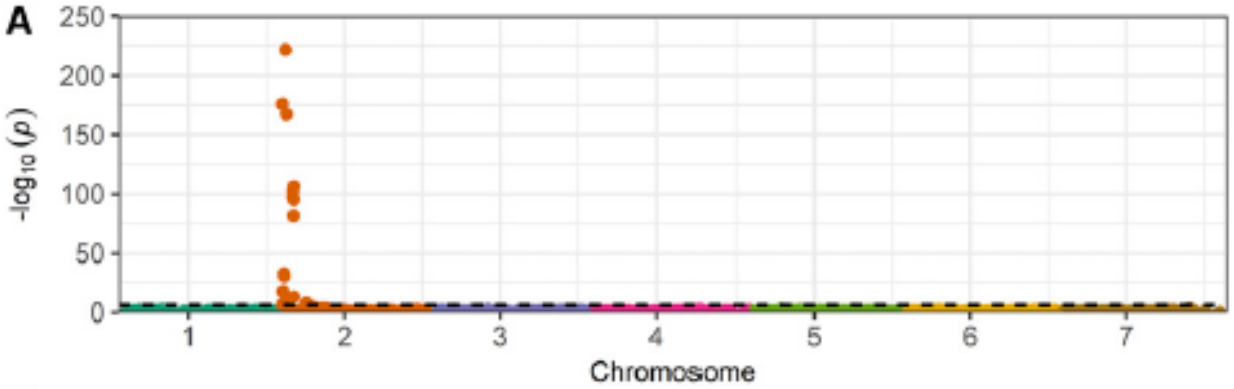
Discovered FW1 resistance QTL
Published in 2018 – G3

Discovered more resistance QTL creating durable resistance to FW Race 1
Published in 2022 -TAG

Genetic marker designs and sources of resistance are available.

Genome-Wide Association Mapping Uncovers *Fw1*, a Dominant Gene Conferring Resistance to Fusarium Wilt in Strawberry

Dominique D. A. Pincot,* Thomas J. Poorten,* Michael A. Hardigan,* Julia M. Harshman,* Charlotte B. Acharya,* Glenn S. Cole,* Thomas R. Gordon,† Michelle Stueven,† Patrick P. Edger,‡ and Steven J. Knapp*,1



Novel Fusarium wilt resistance genes uncovered in natural and cultivated strawberry populations are found on three non-homoeologous chromosomes

Dominique D. A. Pincot[1] · Mitchell J. Feldmann[1] · Michael A. Hardigan[2] · Mishi V. Vachev[1] · Peter M. Henry[3] · Thomas R. Gordon[4] · Marta Bjornson[1] · Alan Rodriguez[1] · Nicolas Cobo[5] · Randi A. Famula[1] · Glenn S. Cole[1] · Gitta L. Coaker[1] · Steven J. Knapp[1]

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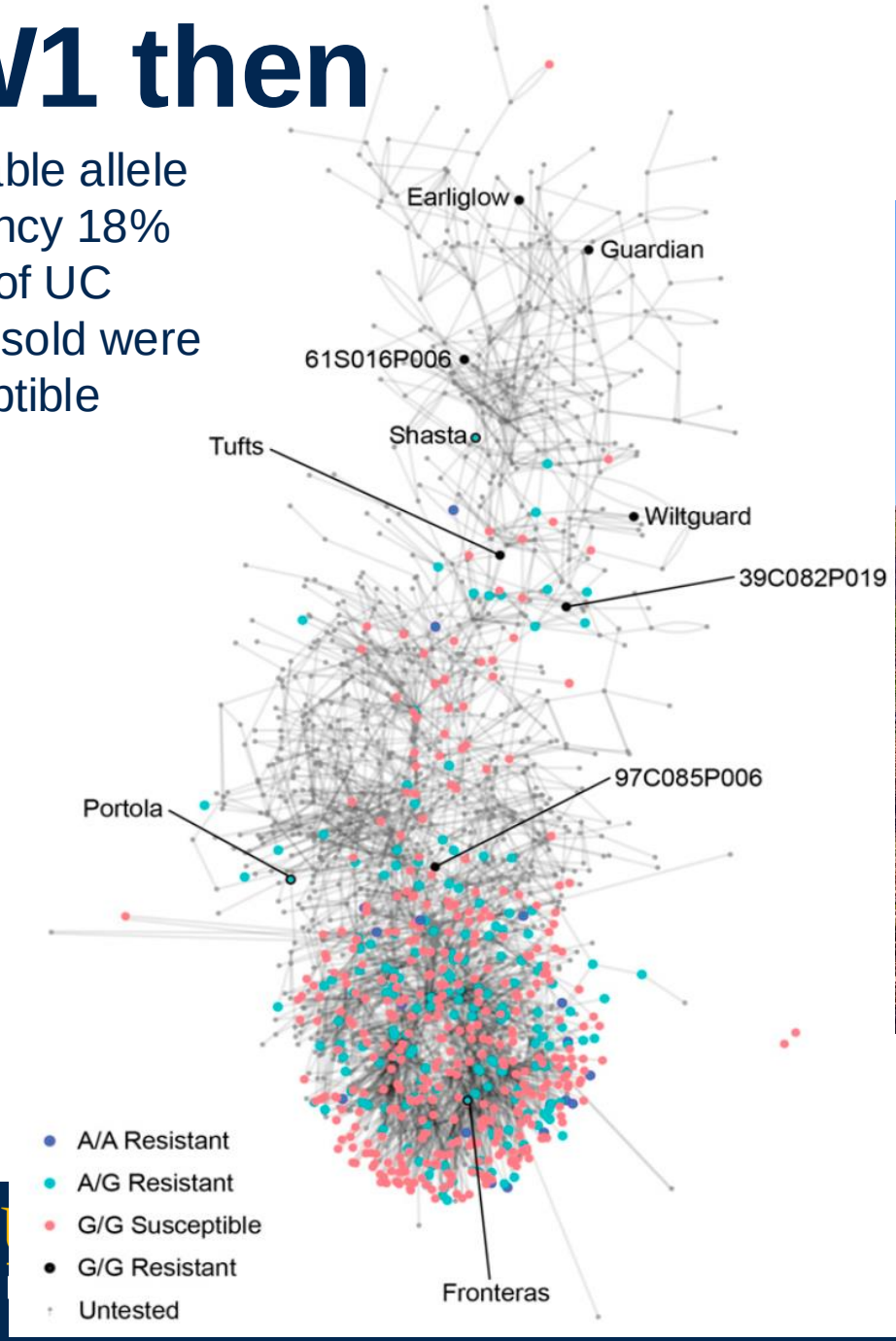
FW1 then

Favorable allele frequency 18%
>50% of UC Plants sold were Susceptible



FW1 Now

present in 99% of resistant individuals in the UC breeding program

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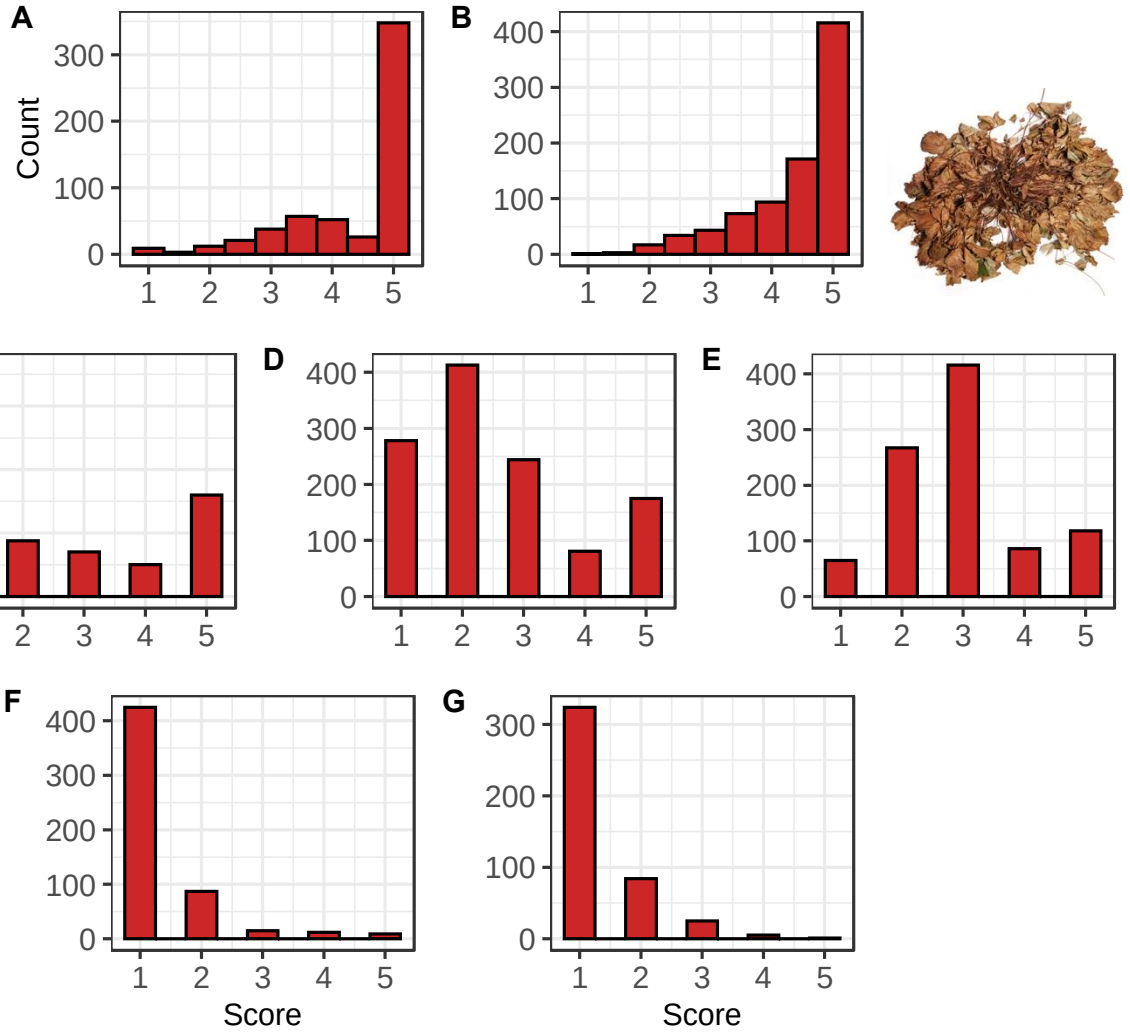
Macrophomina Charcoal Rot

Started studying Macrophomina resistance in 2015.



Discovered **10** resistance QTL

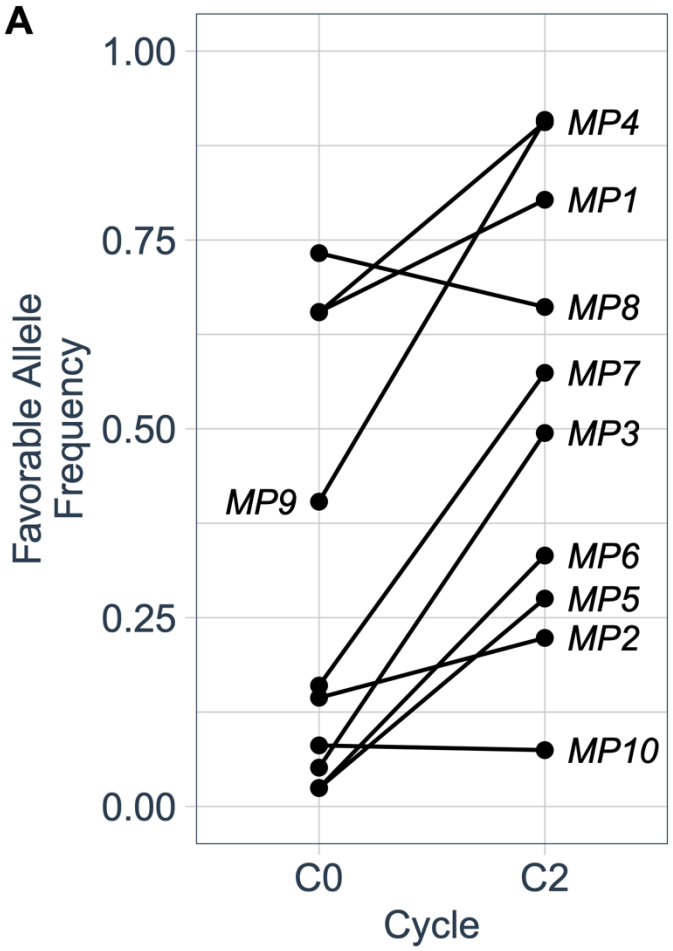
Published 2024- Horticulture Research

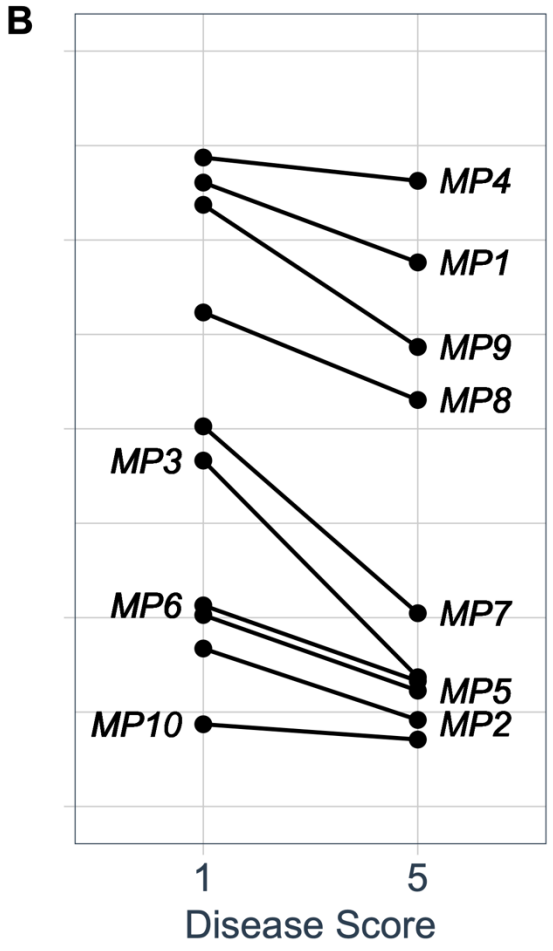
Transgressive segregation, hopeful monsters, and phenotypic selection drove rapid genetic gains and breakthroughs in predictive breeding for quantitative resistance to *Macrophomina* in strawberry

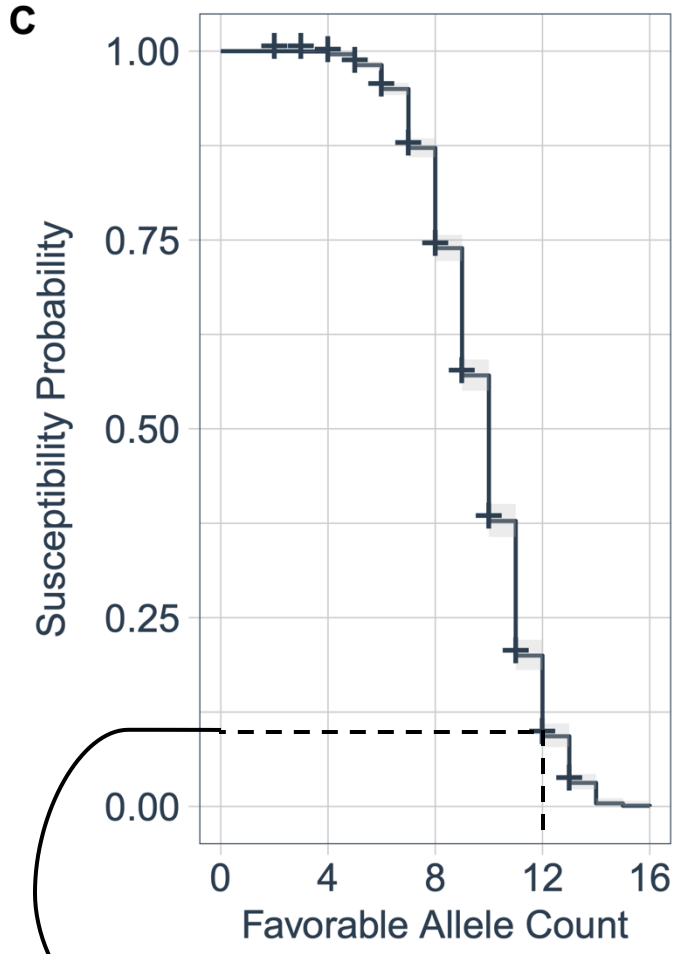
Steven J. Knapp[1,†,*], Glenn S. Cole[1,†], Dominique D.A. Pincot[1,†], Christine Jade Dilla-Ermita[1,2], Marta Bjornson[1], Randi A. Famula[1], Thomas R. Gordon[3], Julia M. Harshman[1], Peter M. Henry[2] and Mitchell J. Feldmann[1,†]

Genetic marker designs and sources of resistance are available.

Concentrating favorable alleles creates plants Resistant to Macrophomina (MAC stack)







12 (+) alleles across 10 loci (60%) yields a **90% probability of survival**

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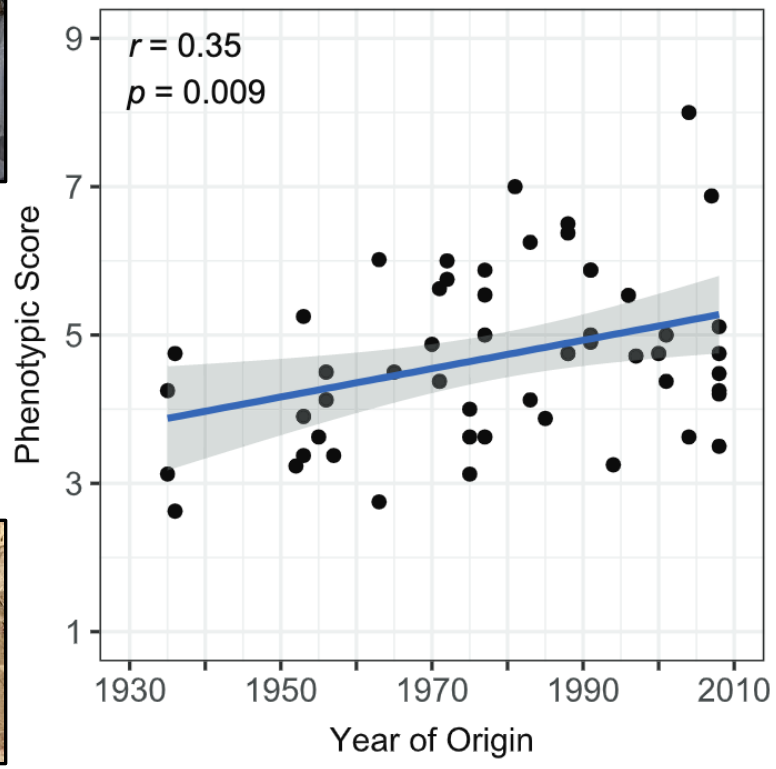
Verticillium Wilt



- Genetic gains in breeding for resistance to Verticillium wilt have been negative over the last 165 years.
- Less than 3% of the germplasm accessions phenotyped were classified as highly resistant.
- The strongest sources of resistance were heirloom cultivars and ecotypes predicted to carry favorable alleles that are not found in modern cultivars.
- No large effect loci. Genomic selection has significant potential to increase genetic gains and accelerate resistance

Accuracy of genomic selection and long-term genetic gain for resistance to Verticillium wilt in strawberry

Dominique D. A. Pincot[1] | Michael A. Hardigan[1] | Glenn S. Cole[1] | Randi A. Famula[1] | Peter M. Henry[2] | Thomas R. Gordon[3] | Steven J. Knapp[1]

Publications 2020 and 2023 – The Plant Genome

Accelerating genetic gains for quantitative resistance to verticillium wilt through predictive breeding in strawberry

Text

Mitchell J. Feldmann | Dominique D. A. Pincot | Mishi V. Vachev | Randi A. Famula | Glenn S. Cole | Steven J. Knapp

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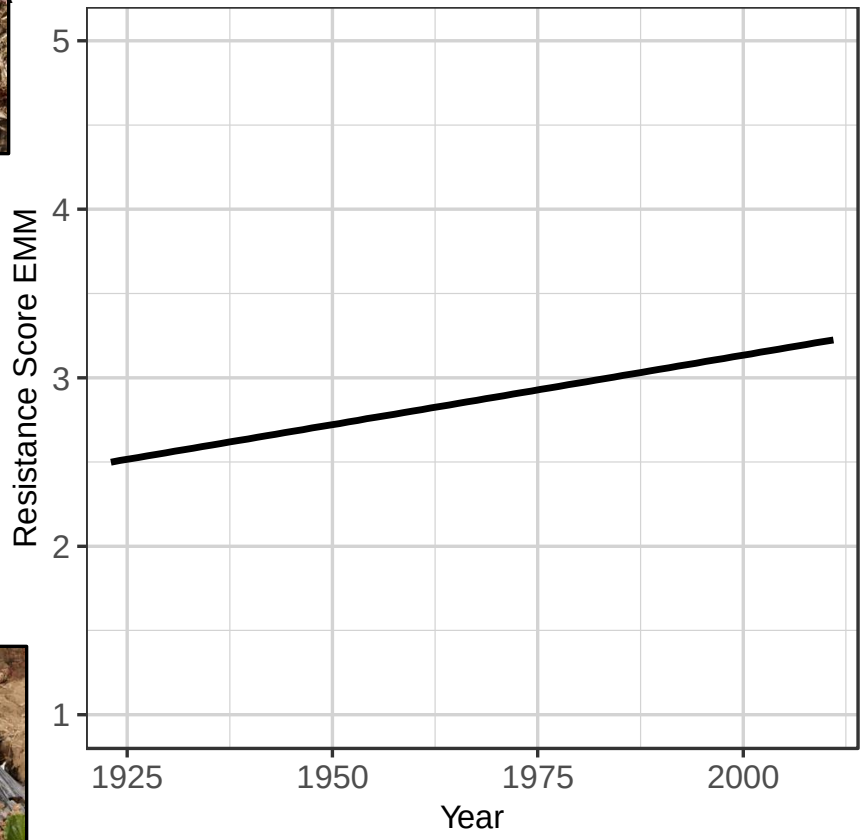
Phytophthora Crown Rot



- Resistance is genetically complex. A large effect locus, (*FaRPc2)* is necessary but not sufficient for resistance.
- Genetic gains can be accelerated by MAS + genomic prediction.
- The strongest sources of resistance were heirloom cultivars developed before the advent of soil fumigation.

2022

ORIGINAL ARTICLE

Harnessing underutilized gene bank diversity and genomic prediction of cross usefulness to enhance resistance to *Phytophthora cactorum* in strawberry

Nicolás P. Jiménez[#] | Mitchell J. Feldmann[#] | Randi A. Famula | Dominique D. A. Pincot | Marta Bjornson | Glenn S. Cole | Steven J. Knapp

Actions speaking louder than words

100% of new UC Davis varieties are **Resistant to Fusarium**
Consumer ratings were better than current commercial varieties.

‘UC Surfline’

Short Day
Early fruiting & yield
Fusarium Resistant

‘UC Monarch’

Extended Short Day
Exposed fruit
Small plant canopy
Fusarium Resistant

‘UC Golden Gate’

Day Neutral
Early to midseason
Excellent shelf-life
Fusarium Resistant

‘UC Keystone’

Day Neutral
Mid-to-late season
High marketable yields
Fusarium Resistant

‘UC Eclipse’

Extreme Day Neutral
Summer plant
Large Fruit
Fusarium Resistant

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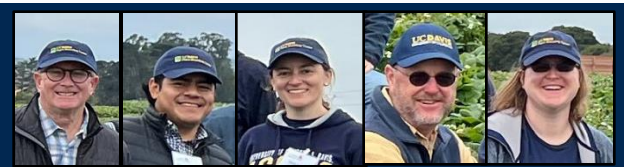


UC Strawberry Breeding Program

Disease Resistance Ratings of UC Varieties

(2016-2024)

1 = Resistant
5= Susceptible

Variety	FUS	MAC	VER	PHY
Albion	4.2	4.7	3.0	3.4
Cabrillo	4.1	4.3	2.8	2.8
Camarosa	4.3	5.0	3.2	3.0
Chandler	3.9	4.7	2.3	3.4
Fronteras	1.3	4.1	2.5	2.5
Monterey	4.0	4.6	2.8	3.3
Portola	1.6	4.0	3.1	2.5
San Andreas	1.1	4.8	N/A	2.4
UC Eclipse	1.1	4.0	2.0	2.6
UC Golden Gate	1.2	4.1	2.8	2.4
UC Keystone	1.4	3.9	2.5	2.2
UC Monarch	1.1	3.1	2.4	2.1
UC Surfline	1.0	3.4	1.5	1.5
UCD Finn	4.5	5.0	3.0	3.7
UCD Mojo	3.1	2.4	2.1	2.6
UCD Moxie	1.4	4.6	2.4	2.9
UCD Royal Royce	3.9	3.5	2.5	2.7
UCD Valiant	3.6	3.7	2.3	2.7
UCD Victor	1.1	4.5	2.8	2.2
UCD Warrior	1.1	3.1	2.4	2.3

Breeding for Organic Growers

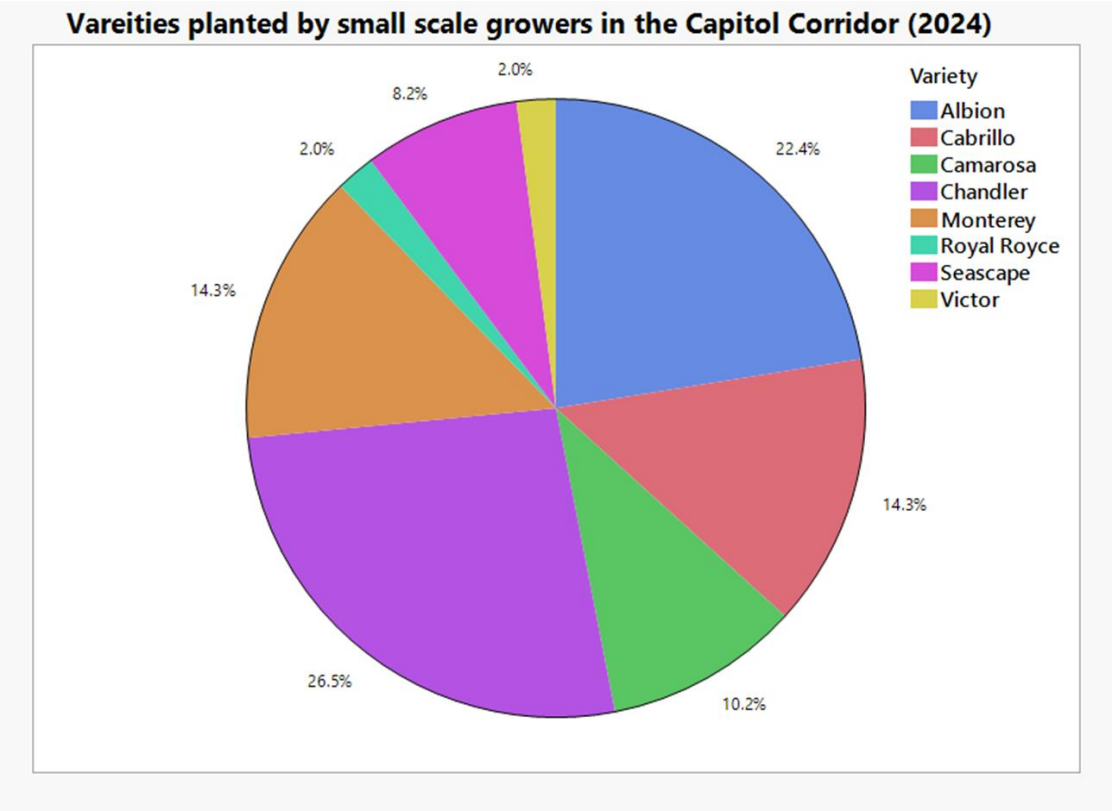
~12% of total CA Organic Acreage for 2023 (CSC)

~60% of fall planted acres are in Watsonville/Salinas Area

~70% Summer planted acres in Santa Maria

Organic Statewide by Variety

Variety	Acreage
Cabrillo	281
% State	5.8%
Fronteras	230
% State	4.7%
Monterey	532
% State	11.0%
Other	79
% of State	1.6%
Portola	935
% State	19.2%
Proprietary	2,608
% State	53.7%
Royal Royce	38
% State	0.8%
San Andreas	73
% State	1.5%
Sweet Ann	46
% State	0.9%
Unreported / Underreported	39
% State	0.8%
Total	**4,860**



Smaller local market growers*

Margaret Lloyd, UCCE Organic Agriculture and Small Farms Advisor. Capitol Corridor, Yolo, Solano Counties

Lindsey Kelly- UCCE Small & Organic Farms, Community Education Specialist.

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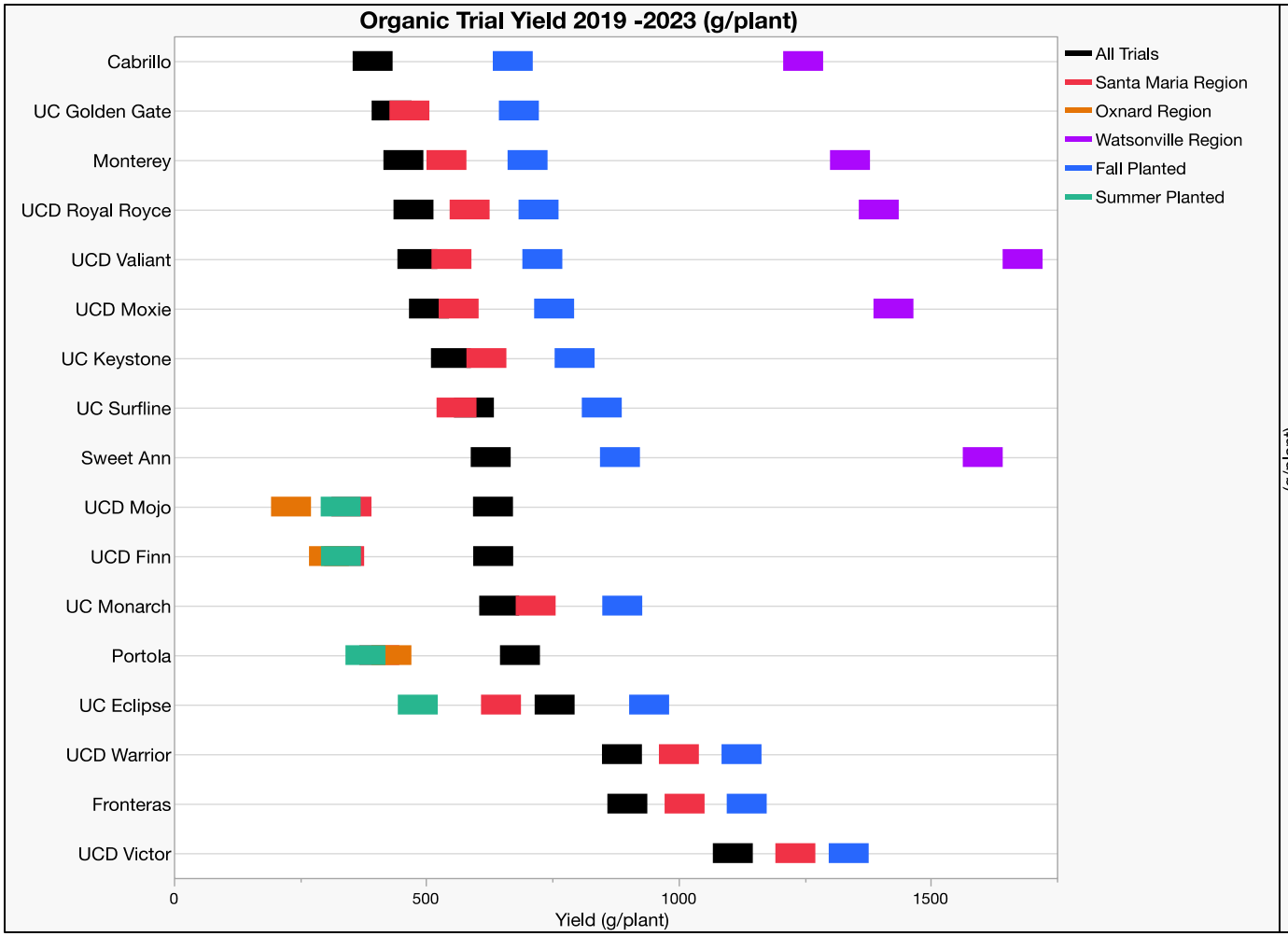
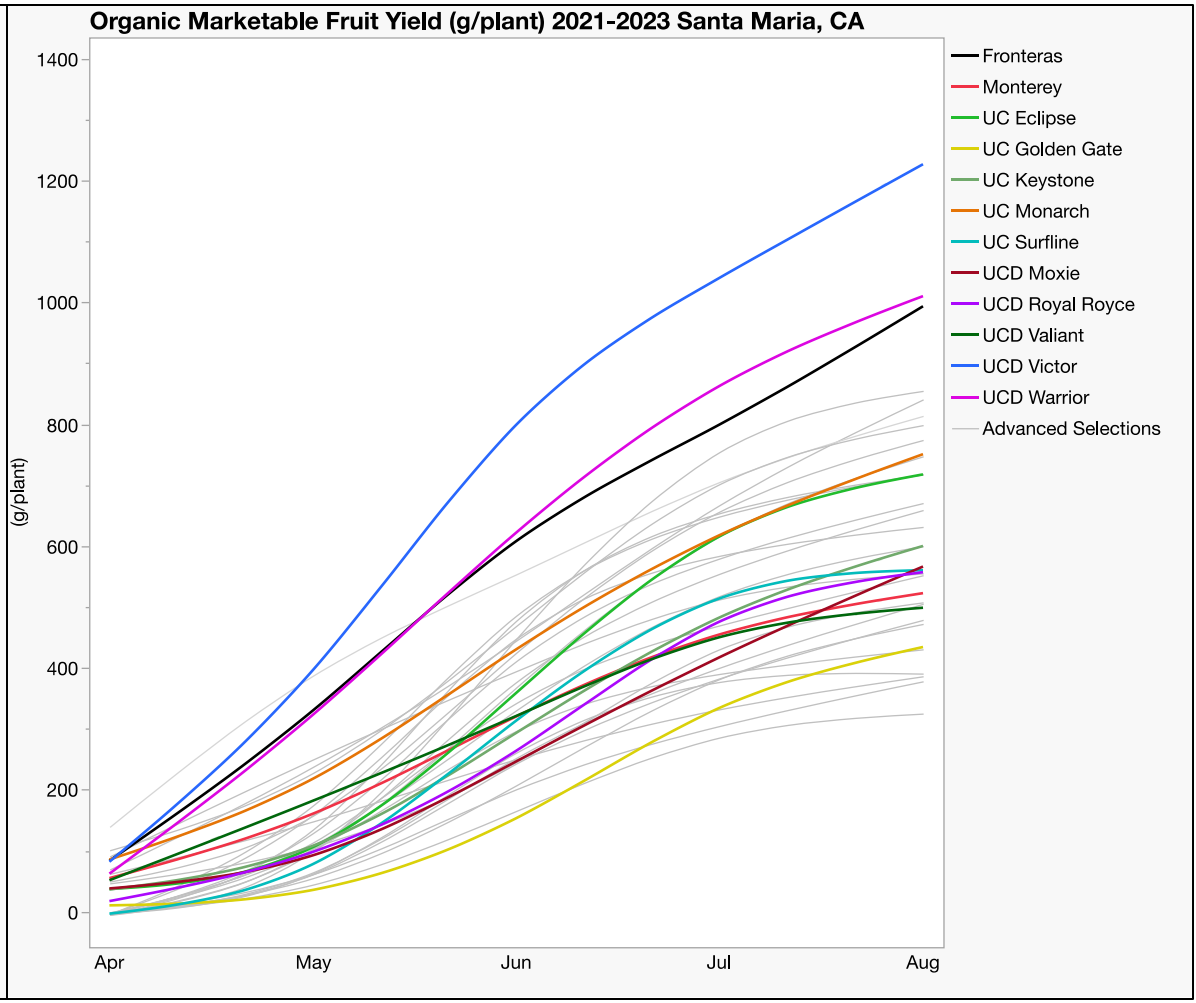
CALIFORNIA STRAWBERRY COMMISSION

Breeding for Organic Growers





Thanks to the Organizer

UC CE University of California Cooperative Extension

Thanks to our supporters, collaborators, and funding agencies!

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