Management practices for control of soilborne pathogens in UC strawberry cultivars

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California strawberry nursery and fruit production regions
High-Elevation Nurseries
Low-Elevation Nurseries
Watsonville/ Salinas
Santa Maria
Oxnard
Orange County
San Diego
Central Valley
Coachella Valley
Klamath
Mt. Shasta
Lassen Peak
COAST RANGES
Sacramento
Feather
Truckee
Carson
Humboldt
Owyhee
Great Salt Lake
Kings Peak
SACRAMENTO VALLEY
SIERRA NEVADA
San Joaquin
Salinas
California Aqueduct
Mount Whitney
Telescope Peak
Delano Peak
MOJAVE DESERT
COLORADO PLATE
San Jacinto
Salt
Gila
SONORAN DESERT

Major strawberry soilborne pathogens

***Phytophthora cactorum* root & crown rot**

Verticillium dahliae

Macrophomina phaseolina

Fusarium oxysporum

***Colletotrichum acutatum** root & crown rot**

***Botrytis** petiole, crown and root rot**

Viruses and phytoplasms*

* Technically not soilborne pathogens

Superior plant quality starts in the nursery…

- Pest- and disease-free plants
  (meristem culture, soil fumigation, BMPs)
- Location, soil type, dig date, handling
- Physiological conditioning (chill, CHO+N levels)
- Plant size / development

…but does not end there

- Plant selection, postharvest handling, transport
- Establishment conditions, methods
- Fruiting field BMPs

Heat treatment

Suppresses viruses and other pathogens

Disease-free meristem plant

Photo courtesy C. Gaines

Meristem Propagation

- Eliminates plant pathogens

- Enhances plant vigor

- Plants derived from meristem culture will remain pathogen-free if kept isolated from sources of contamination (attention to sanitation, BMPs)

Screenhouse propagation

Each meristem plant produces 100-200 daughter plants

Foundation Block - Isolation

Photo courtesy C. Gaines

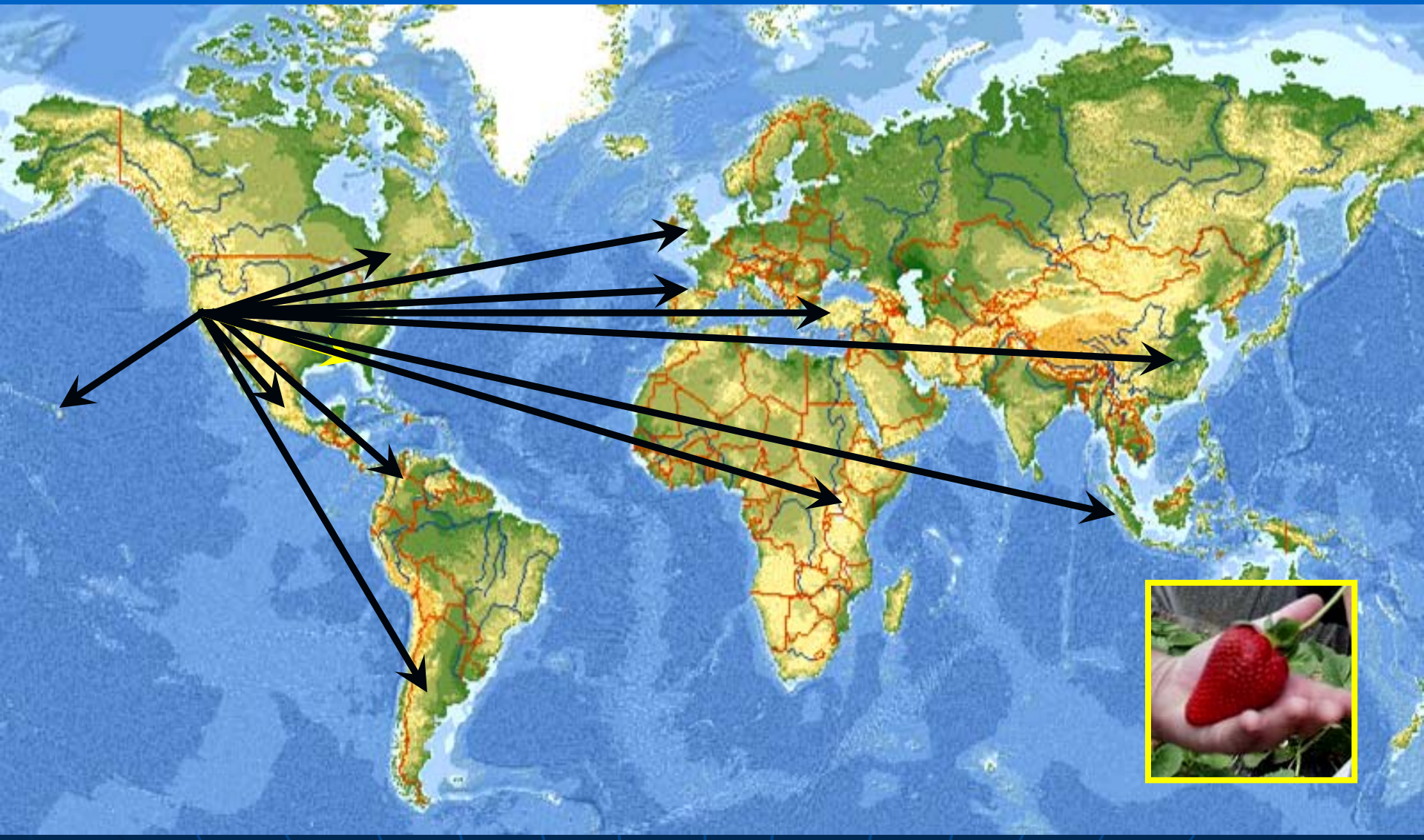
Low elevation increase nursery

Nursery development September 1

High elevation nursery planted April 1 (~10k mother plants/A)

Low elevation nursery planted late May - June (<2k mother plants/A)

California nurseries ship plants worldwide



Generational increase in plant numbers from one meristem

1 meristem plant → 100 Screenhouse daughters

100 Foundation plts X 100 → 10,000 daughters

10,000 LE increase plts X 100 → 1m daughters

1m HE increase plts X 30 → 30m daughters

1 meristem plant can easily generate

30,000,000 plants in four years

Pathogens or off-types can become explosive!

Breeding for disease tolerance/resistance

Helpful & desireable, but not a complete solution:

- high inocula levels can overcome resistance
- resistance to *all* major pathogens is statistically impossible

A combination of horticultural management *and* resistance breeding is likely to be most effective way to minimize harmful effects of soilborne pathogens

Disease resistance scores for UC short-day cultivars, 2004-07

Genotype	Phytophthora resistance (5 = best)	Verticillium resistance (5 = best)	C. acutatum resistance (5 = best)
Camarosa	3.6	2.5	2.6
Camino R	4.4	4.2	3.1
Ventana	2.5	3.0	3.0
Palomar	2.4	3.3	3.2

Resistance score: 5 = most resistant

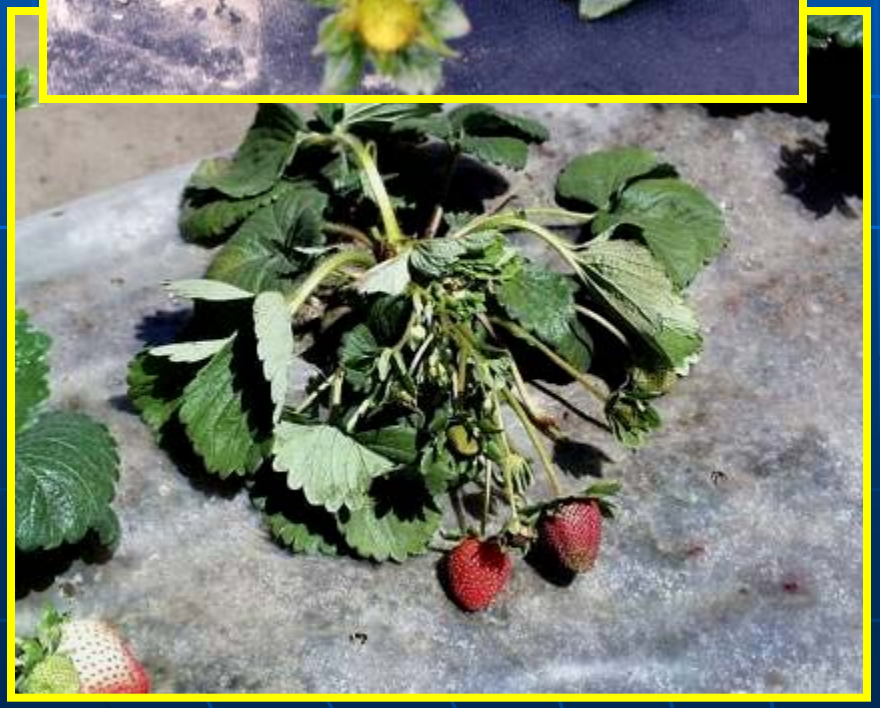
Disease resistance scores for UC day neutral cultivars, 2004-07

Genotype	*Phytophthora* resistance (5 = best)	*Verticillium* resistance (5 = best)	*C. acutatum* resistance (5 = best)
Albion	4.3	3.8	3.4
Monterey	3.2	3.4	2.4
S. Andreas	3.8	3.8	2.9
Portola	4.4	3.3	2.7

Phytophthora cactorum in HE nursery

***Pythium and Phytophthora* are in same general class of fungi**

Phytophthora cactorum in fruiting field



Phytophthora/Pythium control strategies

- Choose well-drained soils and sites – avoid heavy soils and low-lying areas
- Deep rip 3-4 ways
- Pre-plant soil fumigation using the most effective compounds available
- Pre-plant dip with Aliette, Phosgard, etc.
- Regular applications of Phosgard, Ridomil, Aliette
- Irrigate appropriately

Phosphorous acid materials

Phosphorous acid (H_3PO_3, Phosguard, etc.) dissociates into phosphite ion (HPO_3^{-2})

Phosphite readily taken up/translocated in plant but is not converted to phosphate (nutrient)

Phosphite contributes little or nothing to P nutrition of plant

Phosphorous acid fungicides *are* effective against water molds (Oomycetes) such as *Phytophthora* and *Pythium*

Are stable in plant, apply infrequently (~1x/month)

Performance of SD cultivars with or without Phosguard treatments*, Irvine 2006-07

Item	Phos-gard	12# C/A to 3/1	12# C/A to 4/1	12# C/A to 6/1	Size (g)	App (1-5)	Firm (1-5)
Camarosa	Yes	1355	2601	8492	30.8	2.6	3.5
	No	999	2250	8478	30.6	2.6	3.4
Palomar	Yes	1562	3258	8001	30.1	3.8	3.8
	No	1409	2876	7511	30.4	3.8	3.8
Ventana	Yes	1031	2965	8532	30.7	3.4	3.6
	No	990	2880	7839	29.8	3.4	3.5

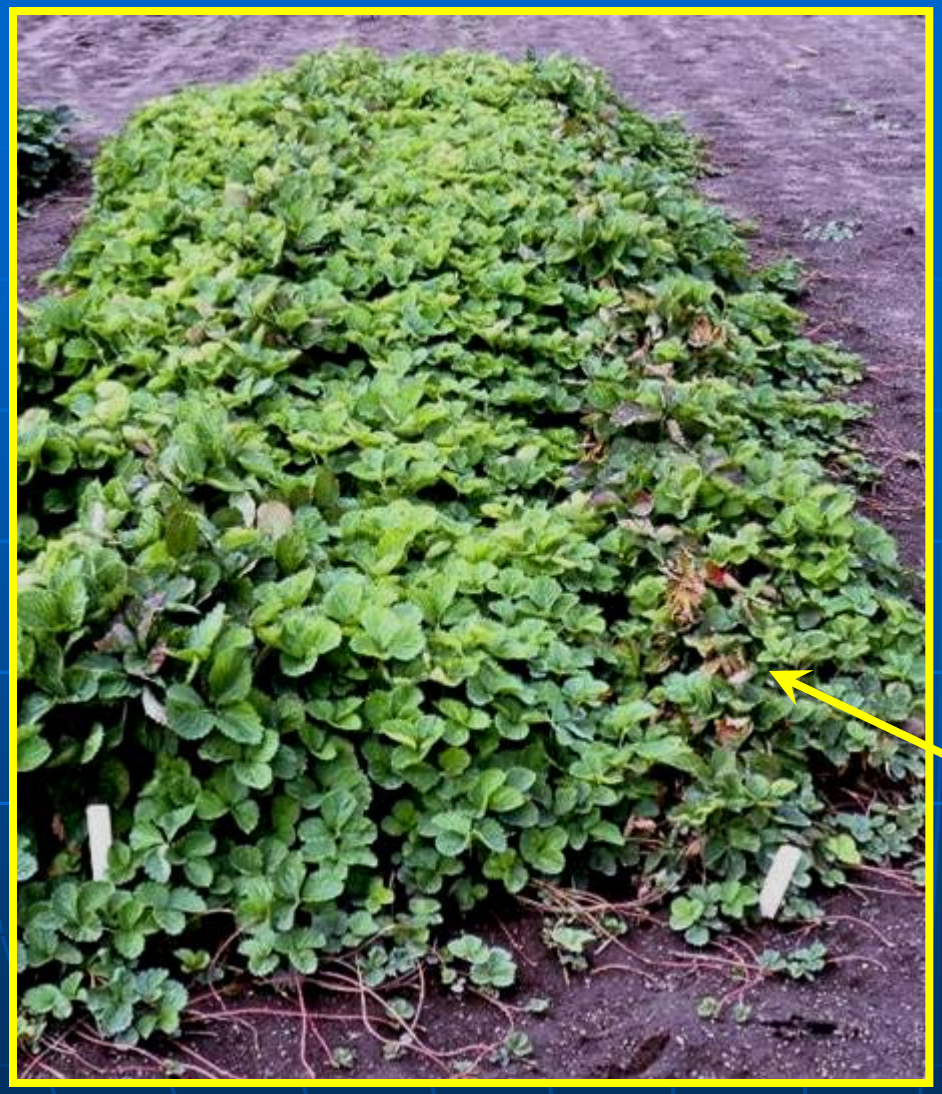
* Phosguard applied as a pre-plant dip, then at monthly intervals through the drip irrigation system

Verticillium in HE transplants

Fumigated and non-fumigated runner nursery plots

No Verticillium wilt

Verticillium wilt



InLine fumigated * HE nursery plot

Note Verticillium symptoms

*445#/a of 2:1 (wt:wt) Telone:chloropicrin

Verticillium control strategies

Avoid crop rotations that include tomato, potato, alfalfa, cotton, olive

Use preplant soil fumigation with highest possible rates of the most-effective fumigants

In strawberry nurseries, apply fumigants in fall rather than in spring

Non-treated

Vapam

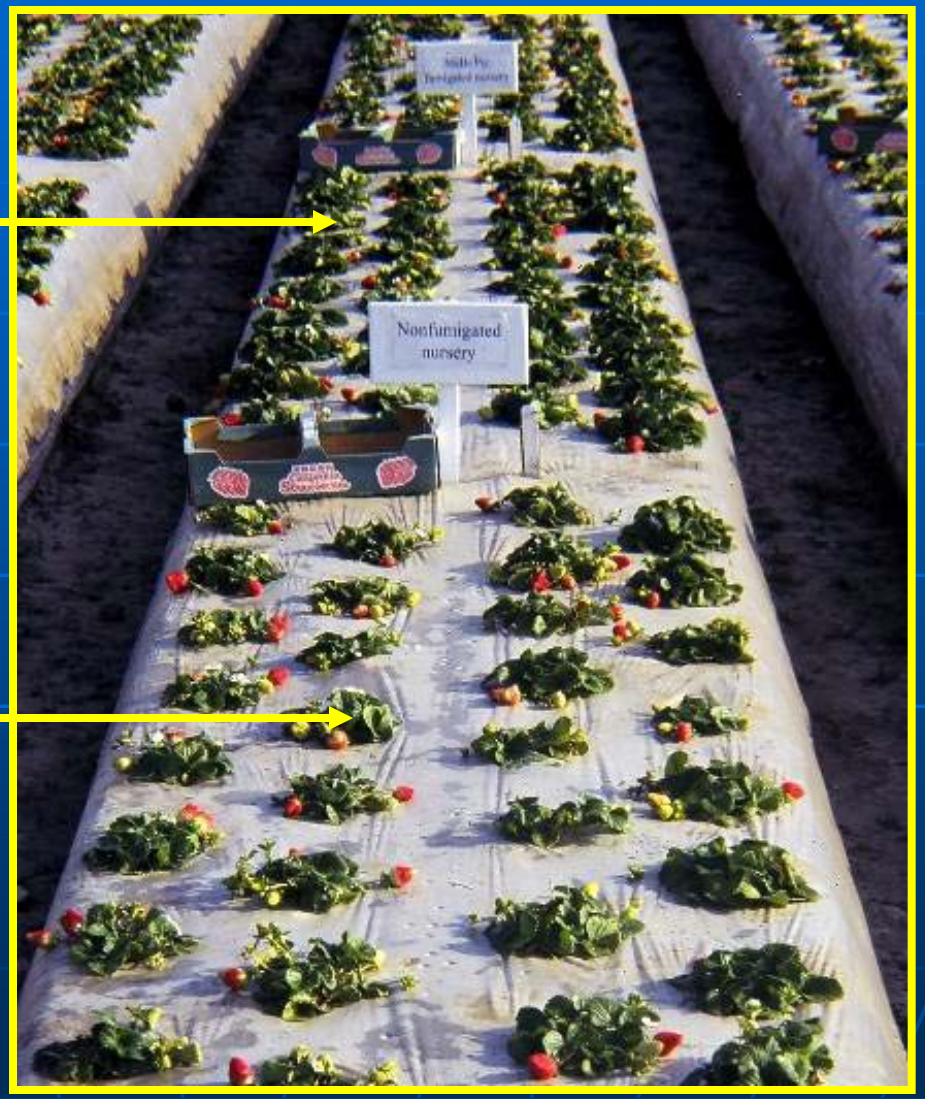
Chloropicrin

Methyl bromide alternatives

Nursery soil fumigation

Transplants from MBPic-fumigated nursery

Transplants from non-fumigated nursery with no detectable pathogens



Macrophomina phaseolina

M. phaseolina

Wide host range **Prefers warm, dry soil**

Variable cultivar susceptibility

2009: Genetic screen (Larson, Gordon, Koike, Shaw)

- **Flat fume with MBPic to eliminate all pathogens**
- **Establish plants of Albion, inoculate with Mp**
- **Incorporate inoculated plants into soil**
- **Establish 50+ HE cultivars and selections**
- **Rate plant vigor and survival**

Also in 2009: Implement fungicide efficacy trials

Establish Albion plants in fumigated soil

Inoculate with Mp

Inoculation, infection and incorporation

Establish replicated plots in clean and infested soil

Control plots

Infested plots

Strategies for controlling Macrophomina

Choose colder sites (?)

Avoid soil water-stress

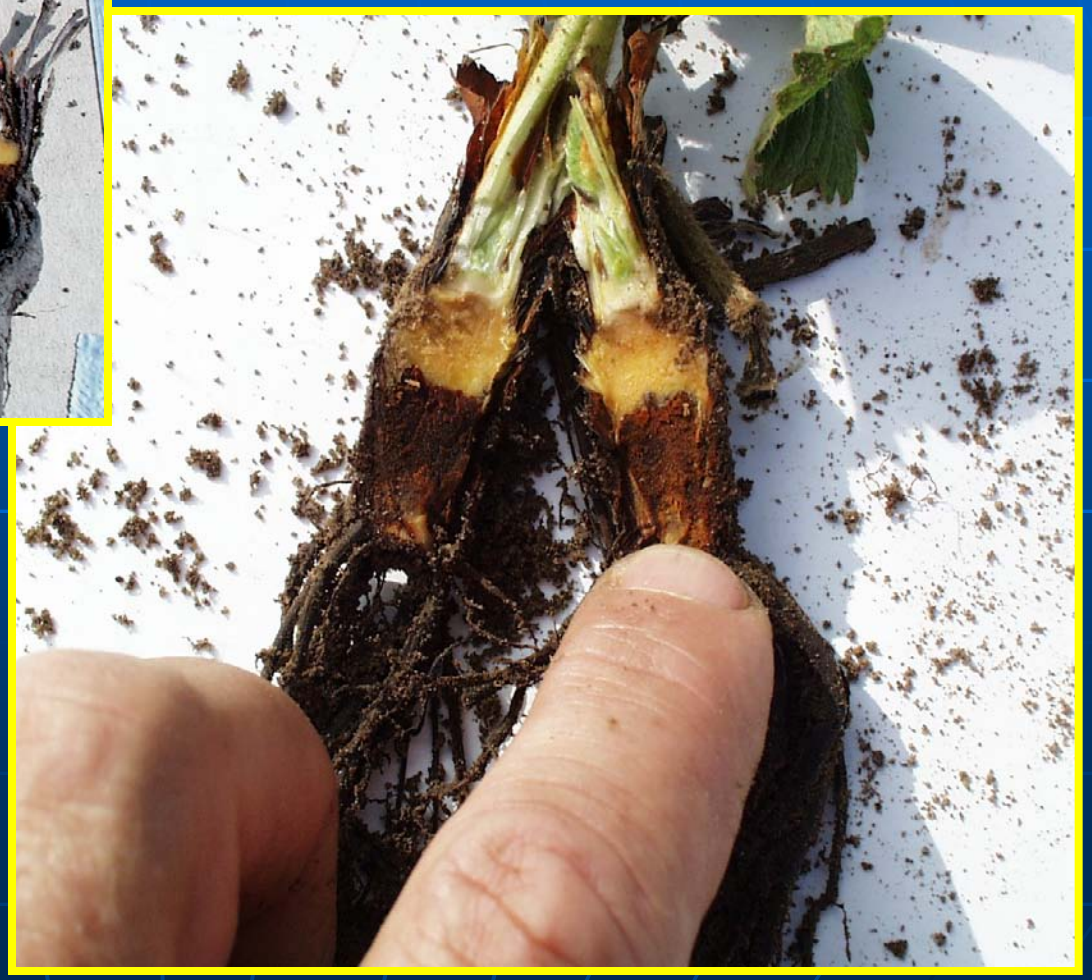
Anecdotal evidence suggests differences in varietal susceptibility

Topsin applications may help suppress Mp

Fusarium oxysporum

Genetic screen similar to Macrophomina screen is being developed by D. Shaw and T. Gordon at UC Davis

C. acutatum
Not a true soil pathogen



Can cause root and crown infection

Transplants infected with C. acutatum

Colletotrichum acutatum
Fruit & flower infection in fruiting field

C. acutatum control strategies

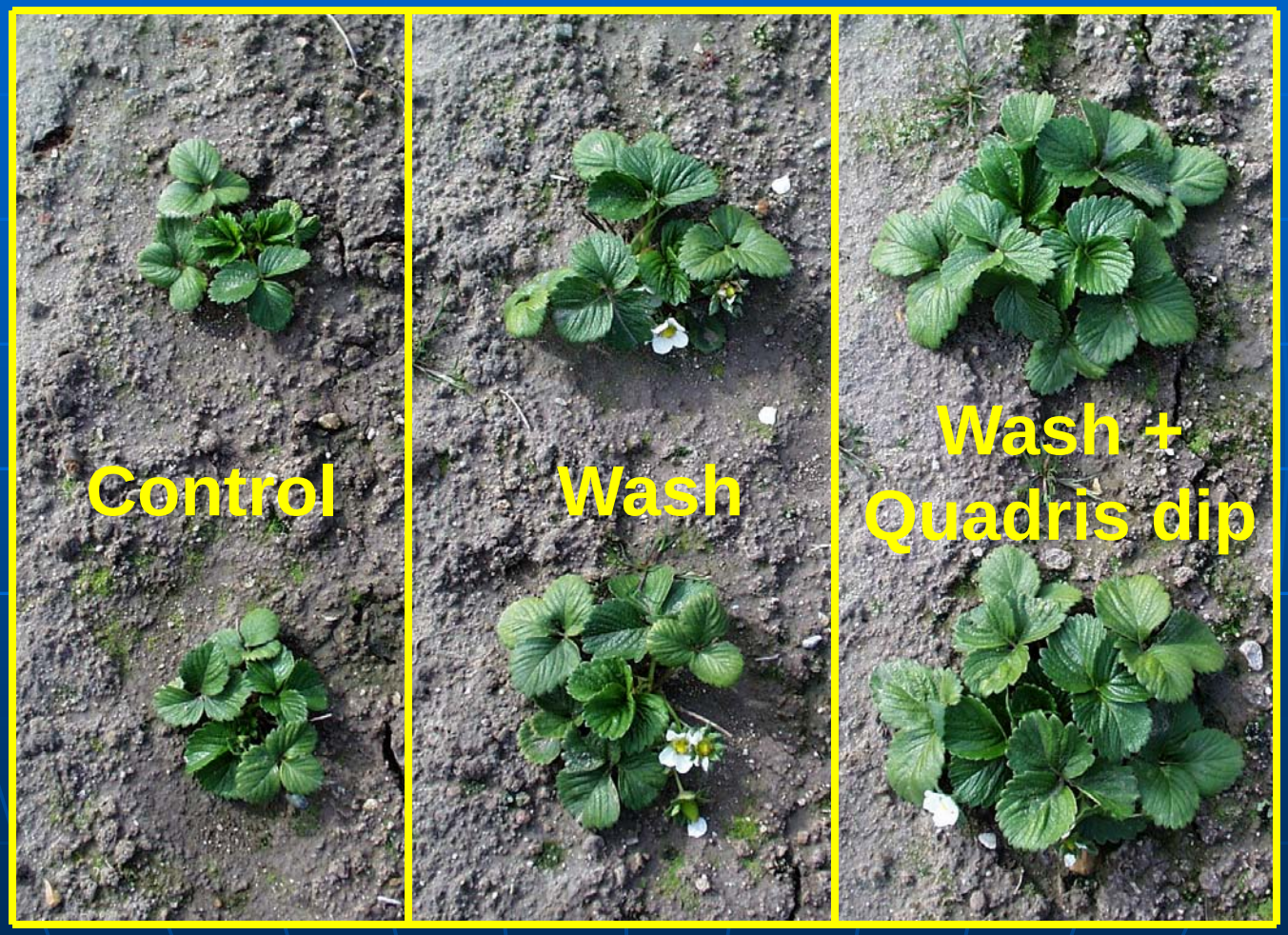
Pre-plant hot-water dip in low-elevation nurseries

Pre-plant fungicide dip
(Abound, Rovral, Topsin, etc.)

Apply foliar fungicides on a routine basis

Move workers from clean to infected fields

Preplant fungicide dip for control of *C. acutatum* and other diseases in nurseries and fruiting fields



Reduces pathogen levels, re-hydrates plants

C. acutatum genetic screen

C. acutatum genetic screen

Cultivar info

Parent selection

Drip-irrigated runner nurseries

Nursery drip irrigation used at SCFS since 1998

Reduces incidence of certain pathogens

Periodic sprinkler irrigation to manage soil salinity

Phytoplasms

Leafhopper-vectored

Viruses

Virus complexes

Vectors: aphids, whitefly, leafhoppers

Control strategies for viruses and phytoplasms

Use systemic and contact insecticides to control aphids, leafhoppers, whitefly:

Admire, Esteem, Disyston, Malathion+Danitol

Eliminate weeds that can be host plants

Isolation from other strawberry plantings

Botrytis fruit rot

Also: Botrytis petiole, crown and root rot

New UC strawberry (Pomology) website:

http://www.plantsciences.ucdavis.edu/ucstrawberry

THANK YOU!