# Fusarium wilt of lettuce survey and possible interactions with other diseases

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Usually first appears as a patch in the middle of a field that later expands

Stunting, wilting

Yellowing/death of outer leaves

Plants can be infected at nearly all growth stages

# **Internal** symptoms: vascular tissue

Discoloration

Hollowing out

Rot, white residue

Core usually not discolored, occasionally rots

# *Fusarium oxysporum* f. sp. *lactucae*

- Disease-causing ability is host specific
  - *F. oxysporum* f. sp. *lactucae* will only cause disease of lettuce
  - f. sp. = “special form”

- Can grow and reproduce on:
  - Plants on which it cannot cause disease
  - Resistant cultivars of its host plant

- There are many *F. oxysporum* f. sp. ____ of other hosts
  - Also, there are probably many *F. oxysporum* populations that are non-pathogenic

| You have… | Can it cause disease on…? | | Can it grow on roots of…? | |
|---|---|---|---|---|
| | Lettuce | Strawberry | Lettuce | Strawberry |
|  Lettuce Fusarium wilt | YES | no | YES | ? (probably) |
| | *Fusarium oxysporum* f. sp. *lactucae* | | | |
|  Strawberry Fusarium wilt | no | YES | YES | YES |
| | *Fusarium oxysporum* f. sp. *fragariae* | | | |

Henry et al. 2019 10.1094/PHYTO-11-18-0418-R

# Colonization of lettuce cultivars and rotation crops by the Fusarium wilt pathogen

| Plant | Root cortex[1] | | Root stele[1] | |
|---|---|---|---|---|
| | % pieces infected | Pathogen colonies per gram | % pieces infected | Pathogen colonies per gram |
| Spinach | 67 ab[3] | 11.5 a | 50.0 b | 8.8 b |
| Cauliflower | 33 a | 2.6 a | 7.4 a | 1.1 a |
| Broccoli | 33 a | 3.0 a | 0.0 a | 0.0 a |
| Lettuce King Henry[2] | 93 b | 576.0 b | 71.0 b | 17.0 b |
| Lettuce Salinas[2] | 100 b | 1312.0 b | 77.0 b | 325.0 c |

[1] Cortex = outer layer of root, Stele = inner cylinder of vascular tissue
[2] King Henry = Romaine, resistant; Salinas = iceberg, susceptible to Fusarium wilt
[3] Within each column, values the same letter are not significantly different

Scott, McRoberts, Gordon. 2014 10.1111/ppa.12135

Non-host rotation crops can be colonized, but less than lettuce

Within lettuce, resistant cultivar is colonized less than susceptible cultivar

# Fusarium thrives in soil

Maryani et al. 2019 Studies in Mycology

G. Holmes, Cal Poly SLO, Bugwood.org

Structures are produced in abundance in diseased tissue and are added to the soil

# Fusarium thrives in soil

Maryani et al. 2019 Studies in Mycology

G. Holmes, Cal Poly SLO, Bugwood.org

A teaspoon of soil can contain hundreds of resting spores

# Fusarium is spread via infested soil


farmersalmanac.com


G. Holmes, Cal Poly SLO, Bugwood.org

Santa Barbara Co. Ag. Commish


G. Holmes, Cal Poly SLO, Bugwood.org

# Three Primary Factors Affecting Fusarium wilt

- Pathogen density in soil (of resting spore)
- Temperature
- Host susceptibility

# Pathogen density in soil

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More pathogen added to soil by:

- Crops with higher colonization
- # of plantings of highly colonized crop (e.g., multiple lettuce/yr)

# Pathogen density in soil

- Things that decrease pathogen density
  - Solarization: 30 days in summer
    - Tested in Yuma in July-August, where soil temp at 2 in. averaged 116°F

- Things that slow introduction and spread
  - Sanitation: Prevent movement of soil from fields with Fusarium wilt history
    - Any and all: equipment, foot traffic

Matheron and Porchas 2010 10.1094/PDIS-04-10-0296
Scott et al. 2012 10.3733/ca.v066n01p20

# Temperature

- Disease usually prevalent in early planting windows
  - Yuma: disease much less severe for Oct./Dec. plantings compared to Sept.

- Difference in planting date of as little as 1 week can reduce disease (field trials, Davis)

- Strongly favored by warm to hot temperatures
  - Daytime highs above 77F likely increases disease risk

  - Key window: 20 to 25 days after transplant (growth chamber, Davis)
    - Unknown if this can be applied to seeded crops

Matheron et al. 2005 10.1094/PD-89-0565
Paugh and Gordon 2019 10.1094/PDIS-09-18-1614-RE

# Host Resistance and Pathogen Races

- Different ability of:
  - Host to resist or tolerate pathogen
  - Pathogen to cause disease on host

| | *F. oxysporum f. sp. lactucae* race | | | |
|---|---|---|---|---|
| **Differential host** | **1** | **2** | **3** | **4** |
| Patriot | S | S | S | IR |
| Costa Rica No. 4 | HR | S | S | S |
| Romabella | HR | HR | S | IR |
| Banchu Red Fire | S | HR | S | IR |

S = susceptible, IR = intermediate resistance, HR = highly resistant

International Seed Federation Oct 2019 (proposal to add additional cultivars are pending)

# Host Resistance and Pathogen Races

- Four races of *F. oxysporum* f. sp. *lactucae* have been identified worldwide
  - 1: Japan
    - Taiwan, Iran
    - Europe (Italy, Portugal, Spain)
    - South America (Brazil)
    - North America (Florida, California, Arizona)
  - 2: Japan
  - 3: Japan, Taiwan
  - 4: Netherlands
    - Europe: Belgium, United Kingdom, Italy, Ireland

# Monitoring the population of the lettuce Fusarium wilt pathogen and occurrence of the disease with Pythium wilt


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## Main Question

**Has a new strain or race of *F. oxysporum* f. sp. *lactucae* emerged?**


## Collaborators

Richard Smith, JP Dundore-Arias, Yu-Chen Wang

Kelley Richardson, Frank Martin, Jim McCreight, Nick LeBlanc

## Additional Thanks

Growers, shippers, PCAs, seed companies, others who sent samples and/or invited us into fields

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Location w/ Expected Race 1 reaction







Location C (possible variant)







Patriot | Stagecoach | Armstrong | San Miguel | Newcastle | Primo | Banchu Red Fire

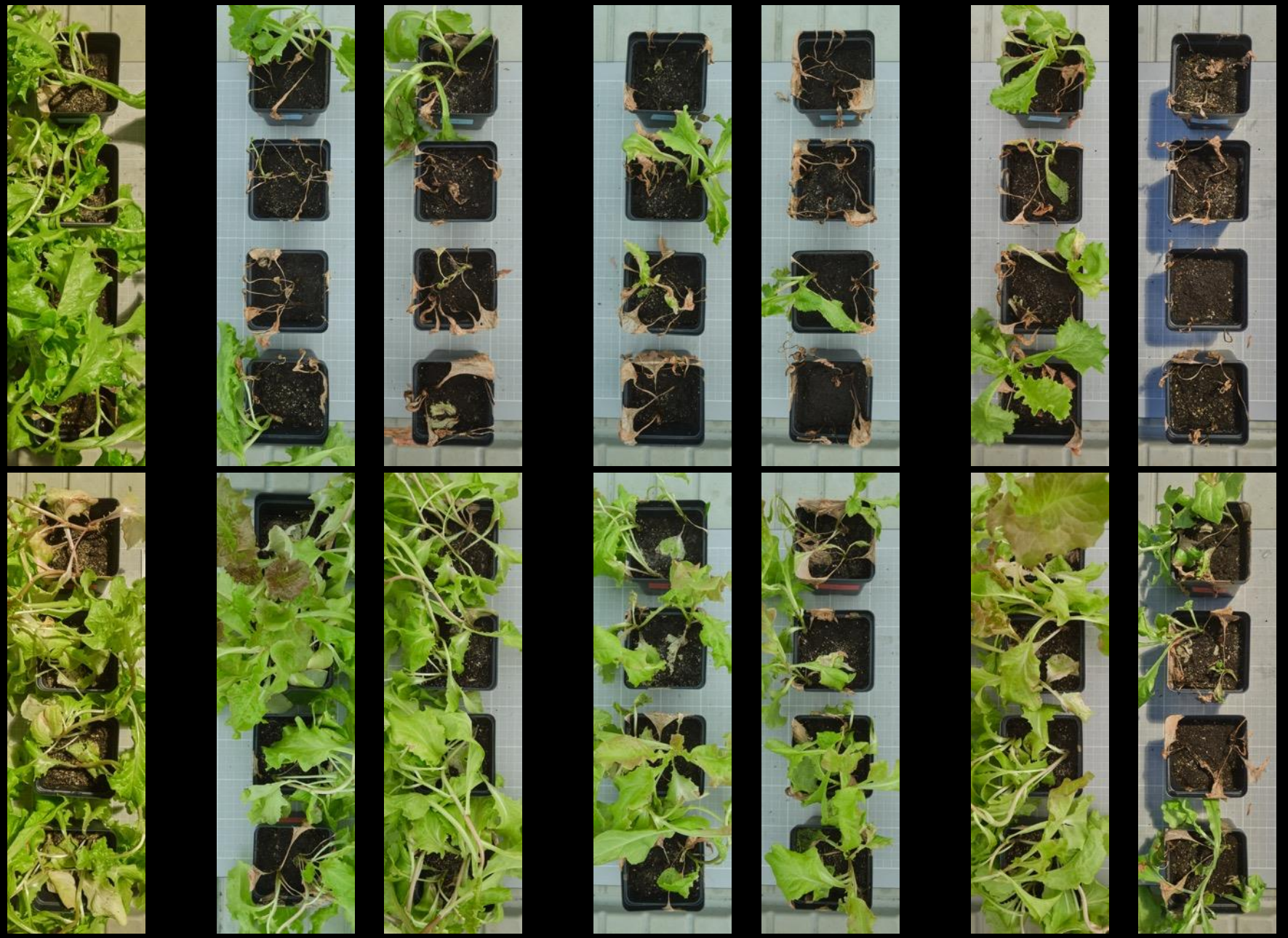
Thanks to:
Dan Riley (Holaday Seed)
David Duke (Salinas Valley Seeds)

Patriot

(susceptible to all races)

Banchu Red Fire

(susceptible to race 1)



Water | Isolate A1 | Isolate A2 | Isolate C1 | Isolate C2 | Isolate J1 | Isolate J2

Location A | Location C | Location J

Location A: Suggests pathogen is not race 1. Results agree with Kelley Richardson (USDA)

Location C: Possible intermediate reaction

Location J: Different reactions from same field, one of which is similar to Loc A

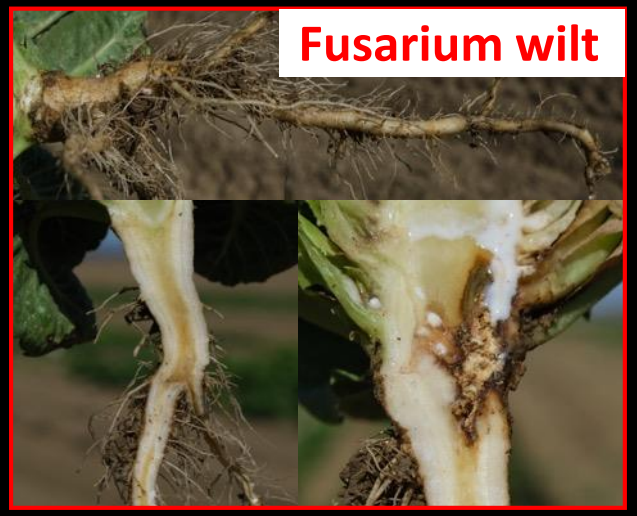
Caveat: These results need to be repeated, then validated in other labs

# Fusarium race survey - Next Steps

- Researchers
  - Repeat and validate in greenhouse race typing tests
  - Determine distribution of possible variant
  - Develop diagnostic assay
- Growers
  - Consider planting small plot or bed demonstration trials in fields with a known history of Fusarium wilt
  - Select a short list of cultivars as in-field indicators

# Interactions with other diseases?

- Diagnosis of soilborne diseases (wilt, root rot, collapse) can be difficult
- Symptoms of Fusarium wilt have been seen to co-occur with symptoms of Pythium wilt




## Objective

Assess the frequency of concurrent Fusarium wilt and Pythium wilt symptoms in soilborne disease outbreaks in the Salinas Valley


Fusarium-Pythium

# Fusarium-Pythium Survey Methods

- Target: as soon as symptoms are first seen in field

- Pick plants ranging from mild to severe symptoms
- Carefully dig up entire plant, shake or wash off soil
- Visually assess symptoms
  - Outer surface: root rot (typical of Pythium wilt)
  - Internal: vascular discoloration (typical of Fusarium wilt)
- Perform lab diagnosis on a subset of samples

- Goals:
  - Determine if symptoms found together
  - If so, which disease appears to be “first”

# Fusarium-Pythium Survey

4 iceberg fields in Monterey County

| | | | | | Visual Diagnosis (% plants) with INSV/without INSV | | | |
|---|---|---|---|---|---|---|---|---|
| | **Region** | **Date** | **Variety** | **# plants** | **Fusarium wilt** | **Pythium wilt** | **Both Fusarium and Pythium** | **Other** |
| A | North | July 26 | Spyglass | 24 | 0/100 | 0/0 | 0/0 | 0/0 |
| B | Mid | July 27 | Salute | 10 | 0/100 | 0/0 | 0/0 | 0/0 |
| | | | Newcastle | 10 | 10/90 | 0/0 | 0/0 | 0/0 |
| C | Mid | July 27 | - | 12 | 0/42 | 42/0 | 0/8 | None 0/8 |
| D | North | Aug 9 | Blackhorse | 21 | 19/57 (w/ corky root) | 0/0 | 5/0 (w/ corky root) | Corky root 0/14<br>None 0/5 |

NOTE: these results are based on visual symptoms only
INSV results are likely an underestimate of INSV infection

# Some early takeaways

- Relatively common to see multiple symptoms in same field or on same plant
- Vascular discoloration does not always mean Fusarium or Verticillium
- Primary pathogen not always obvious