Update on Spinach Diseases: Downy Mildew, INSV, Pythium, and leaf spots

2024 Pest Management Meeting
UCCE Monterey County
November 14, 2024
Salinas, CA

Jim Correll
Department of Plant Pathology
University of Arkansas, Fayetteville, AR
USDA/ARS Salinas, CA

UNIVERSITY OF ARKANSAS
DALE BUMPERS COLLEGE OF AGRICULTURAL, FOOD & LIFE SCIENCES

Overview of Diseases

- Downy mildew testing
- IWGP – Past, Present, Future
- IWGP – Meeting Oct 10, 2024
  - Race 20 press release
  - Several new novel races nominated
  - Several deviating isolates being evaluated
  - Discussion of eliminating older races
- Mildew Screening of commercial germplasm
  - Recent reports of (Yuma and Salinas Trials – 2023 and 2024)
- INSV on Spinach
- Pythium uncinulatum and various Pythium species on spinach
- Leaf Spot Diseases
- Compendium of Spinach Diseases – 2024 (Being finalized)
- International Spinach Meeting 2025?

Peronospora effusa (Pfs)

Lifecycle of *Peronospora effusa*, the spinach downy mildew pathogen

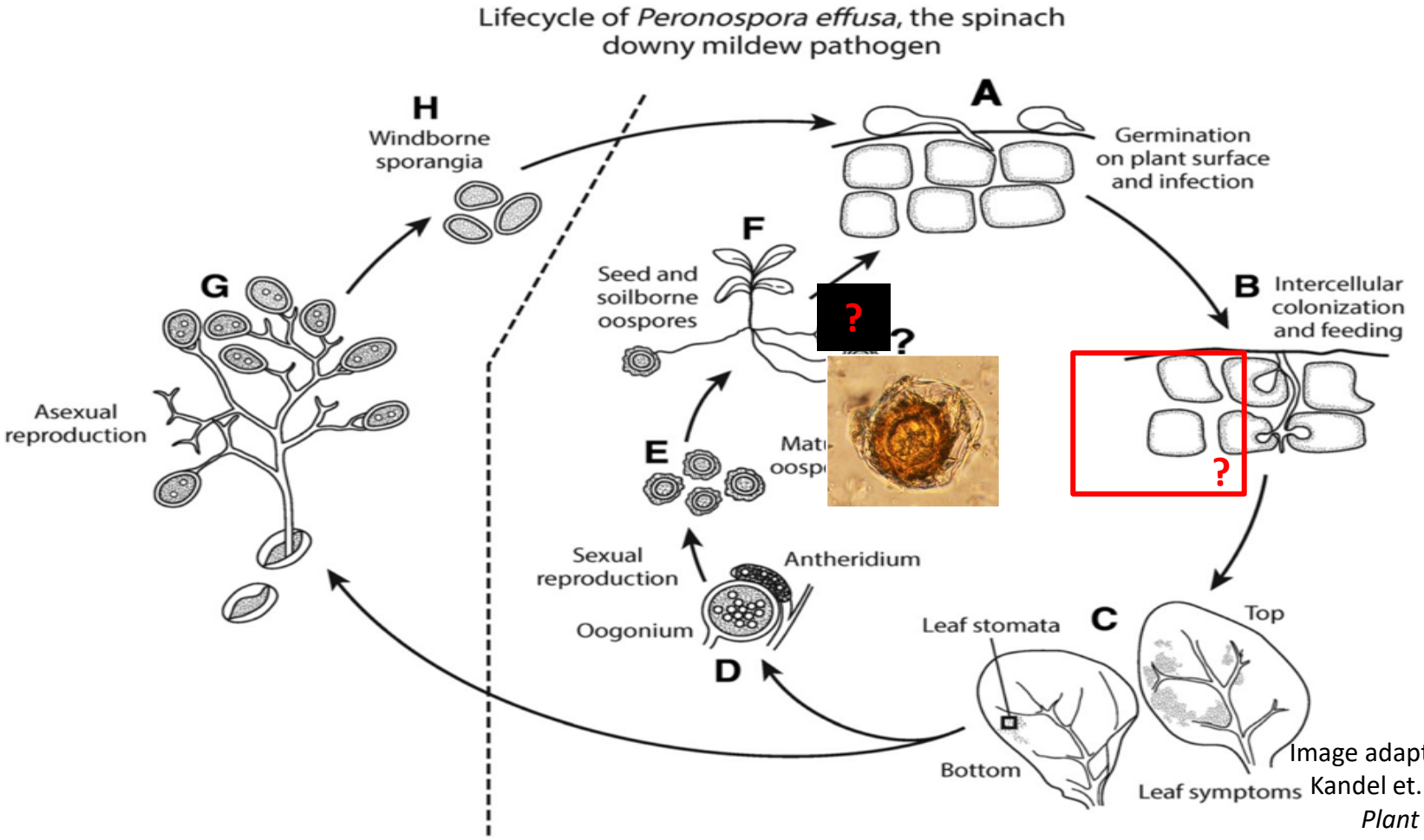


Image adapted from Kandel et. al. 2019 *Plant Disease*.

Downy Mildew
Peronospora effusa

- Global pathogen
- Obligate oomycete pathogen
- Spinach – only host
- Favored by cool-wet weather
- Tolerant of hot / dry
- Short latent period (6-8 days)

International Working Group on Peronospora (IWGP)

- Meet annually to discuss downy mildew isolates
- October 10, 2024
- Reports on novel isolates of economic concern
- Press Release in May 2024 of race 20
  - Joint press release in the U.S. and the E.U.
- Several novel isolates are currently being evaluated
- Concern over newer varieties getting infected
- Proposal to remove earlier races from testing
  - Races 1, 2, and 3

Press Release

PRESS RELEASE

Plantum

Gouda (The Netherlands), 13th of May 2024

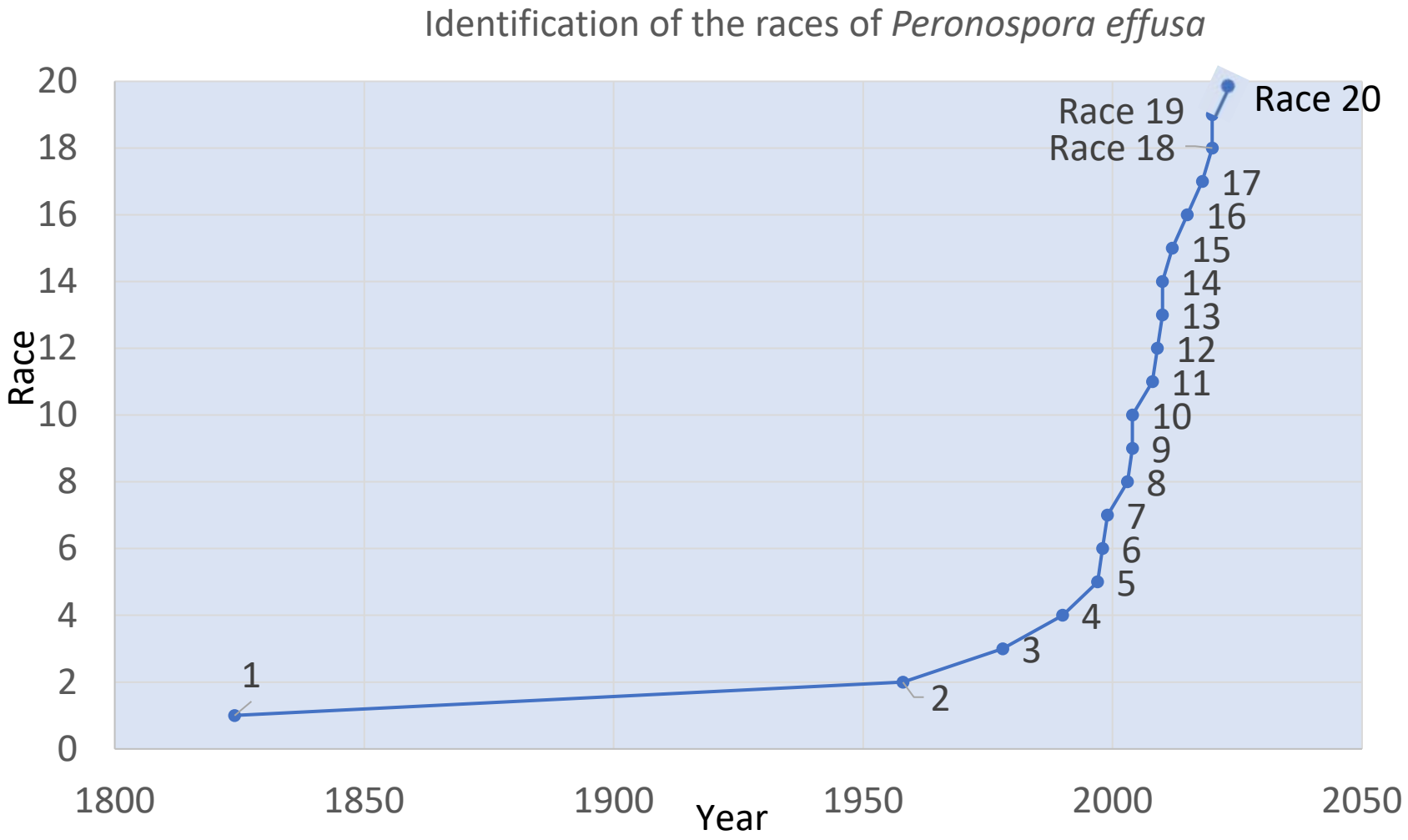
Denomination of Pe: 20, a new race of downy mildew in spinach

Consistent, clear, and timely communication about new races of the spinach downy mildew pathogen is the common interest and aim of all members of the International Working Group for *Peronospora effusa (Pe)* (IWGP). The group fosters a uniform evaluation of Pe field isolates in different parts of the world and integrates and evaluates all information about Pe diversity continuously. Many Pe isolates with the same new virulence pattern have been reported from the USA and Europe in 2023, prompting IWGP to denominate race Pe: 20 today.

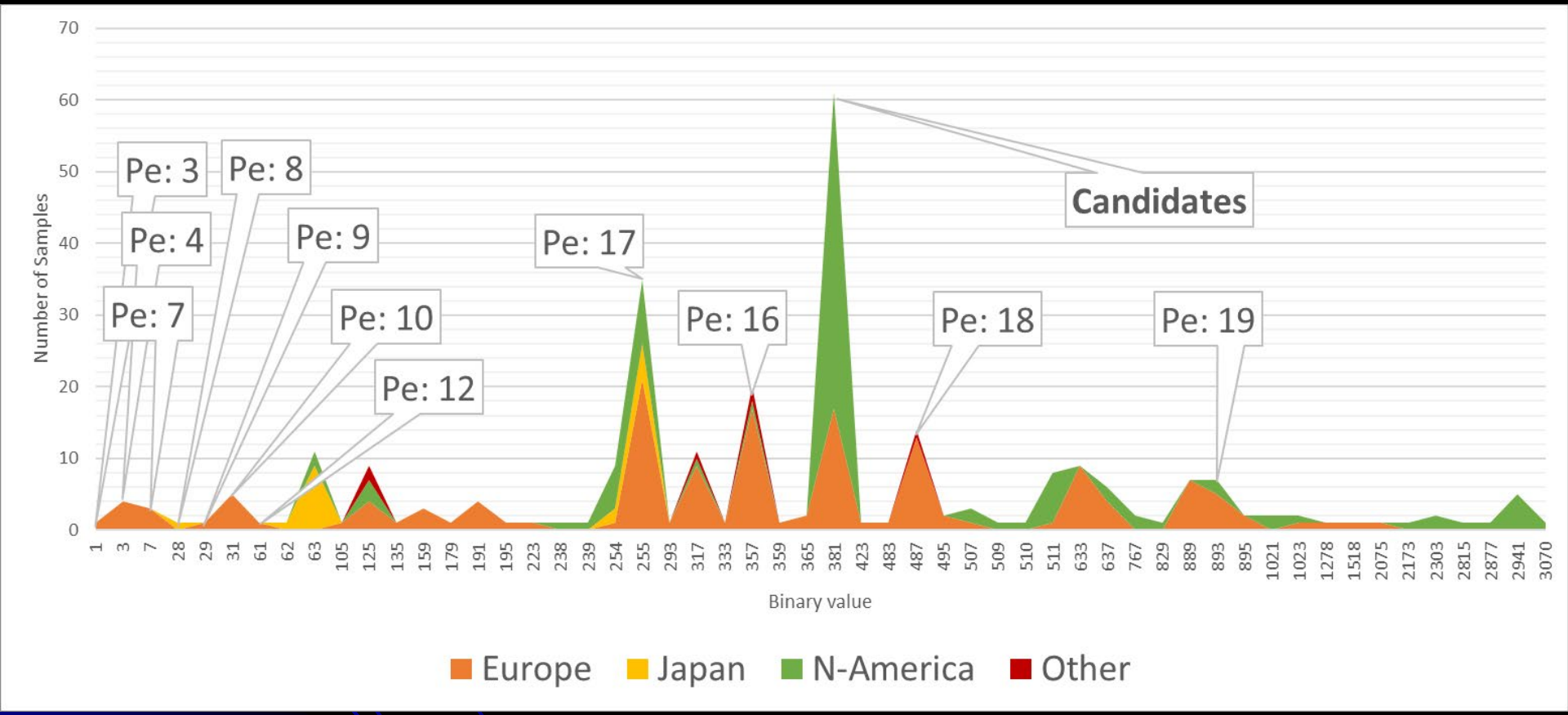
Race 20 - Yakalo

Table: Reaction phenotypes of Pe isolates to IWGP differentials.
Resistance is indicated by the symbols - or (-), susceptibility by the symbol +

	Viroflay	NIL 5	NIL 3	NIL 4	NIL 6	NIL 1	NIL 2	Pigeon	Caladonia	Meerkat	Hydrus	Yakalo
Pe: 1	+	-	-	-	-	-	-	-	-	-	-	-
Pe: 2	+	-	+	-	+	-	-	-	-	-	-	-
Pe: 3	+	+	-	-	-	-	-	-	-	-	-	-
Pe: 4	+	+	+	-	-	-	-	-	-	-	-	+
Pe: 5	+	+	-	+	-	-	-	-	-	-	-	-
Pe: 6	+	+	+	+	+	-	-	-	-	-	-	-
Pe: 7	+	+	+	+	-	-	-	-	-	-	-	-
Pe: 8	+	+	-	+	+	+	-	-	-	-	-	-
Pe: 9	+	+	-	+	+	-	-	-	-	-	-	-
Pe: 10	+	+	+	+	+	+	-	-	-	-	-	-
Pe: 11	+	+	-	+	-	-	+	-	-	-	-	-
Pe: 12	+	+	-	+	+	+	+	-	-	-	-	-
Pe: 13	+	+	+	+	-	(-)	+	-	-	-	-	-
Pe: 14	+	+	-	+	+	+	+	+	-	-	-	-
Pe: 15	+	+	+	-	-	-	-	-	+	-	-	-
Pe: 16	+	+	-	+	-	-	+	+	-	+	-	-
Pe: 17	+	+	+	+	+	+	+	+	+	(-)	-	-
Pe: 18	+	+	+	+	-	-	+	+	+	+	-	-
Pe: 19	+	+	-	+	+	+	+	+	-	+	+	-
Pe: 20	+	+	+	+	-	-	-	-	-	-	-	+


Identification of the races of *Peronospora effusa*
Race
Year
0
2
4
6
8
10
12
14
16
18
20
1800
1850
1900
1950
2000
2050
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
Race 18
Race 19
Race 20

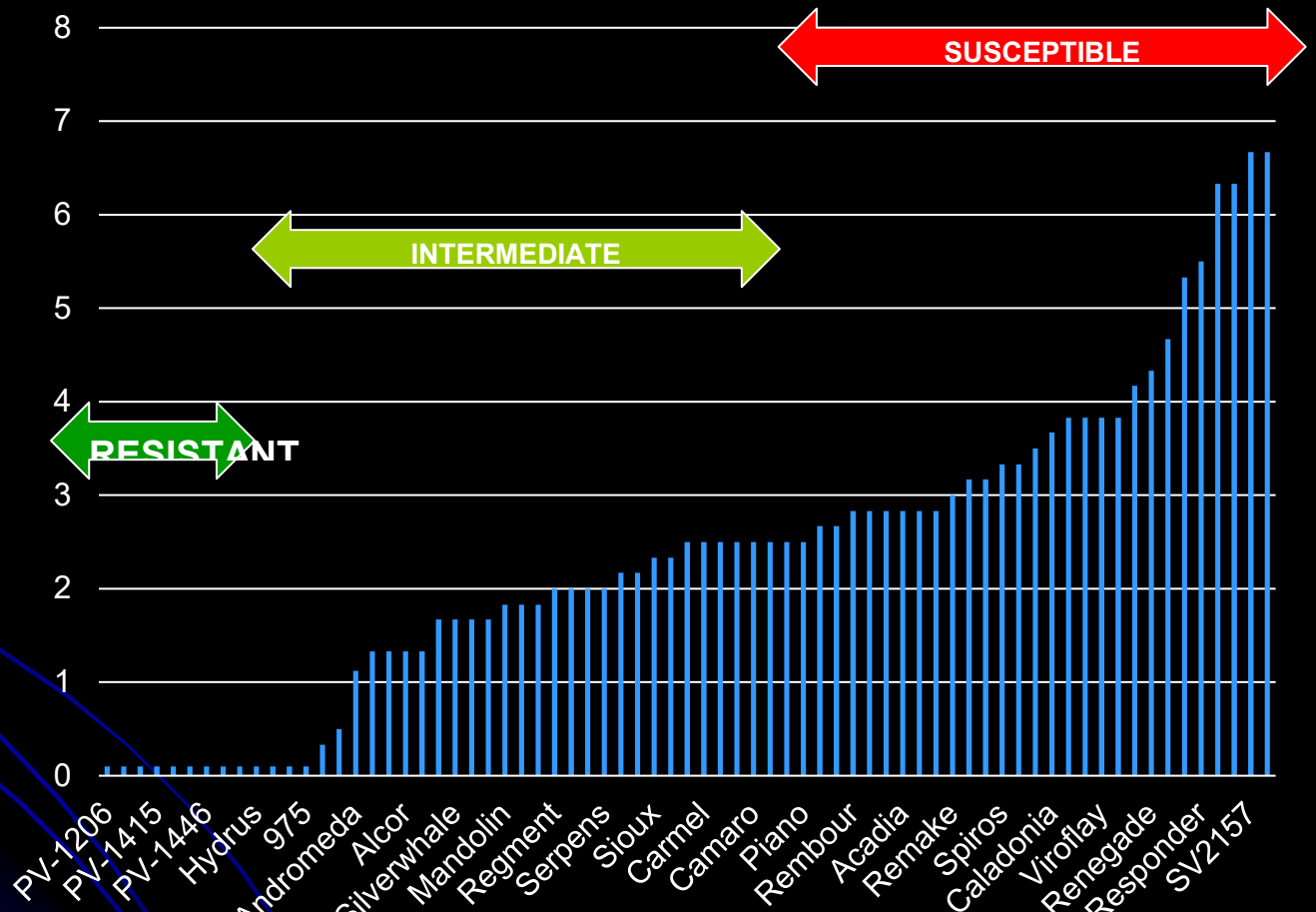
2023
Number of isolates for a given race



Field Testing is Critical
“Sentinel Plots”

Yuma Spinach Field Tests

Yuma, AZ


8
7
6
5
4
3
2
1
0
SUSCEPTIBLE
INTERMEDIATE
RESISTANT
PV-1206
PV-1415
PV-1446
Hydrus
975
Andromeda
Alcor
Silverwhale
Mandolin
Regment
Serpens
Sioux
Carmel
Camaro
Piano
Rembour
Acadia
Remake
Spiros
Caladonia
Viroflay
Renegade
Responder
SV2157

Disease management options

- Host resistance
  - Major (qualitative)
  - Minor (quantitative)
- Cultural
  - Crop Rotation
  - "Green Bridges"
- Chemical
  - Conventional: foliar and seed treatments
  - Organic, limited effective materials, coppers
- Biological - very limited efficacy

Spinach (*Spinacia oleracea* L.)

Male

Female

Hybrid seed production - Denmark

Correll lab

Dr. Maryam Fallahi

- Grew up – Tehran, Iran
- Undergrad – University of Tehran, Plant protection
- Graduate – University of Tehran, Plant pathology
- post-doctoral researcher – MFU University (2022-2023)
- post-doctoral researcher– University of Arkansas (2024)

INSV on Spinach?

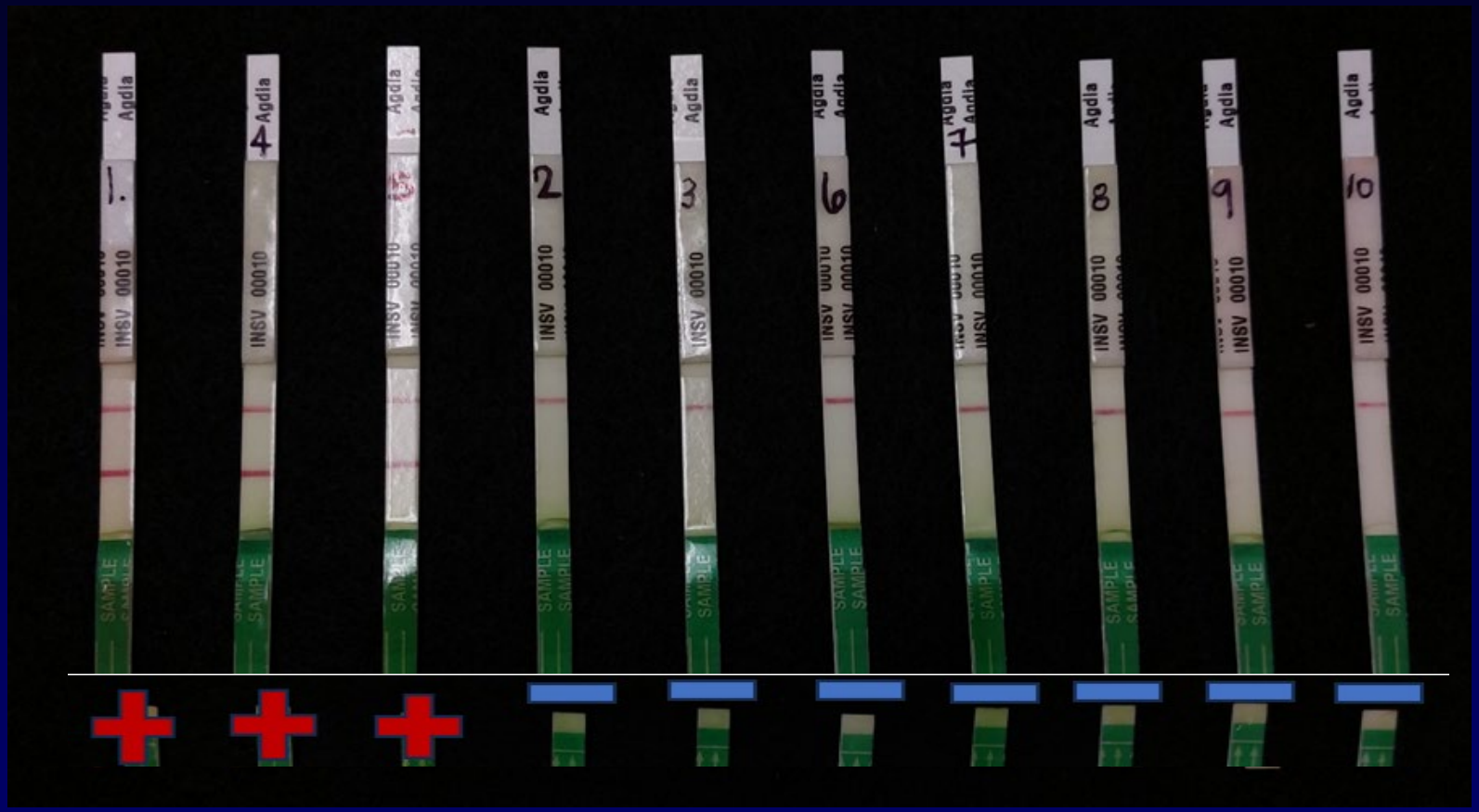
- Input and advice: Drs. Kelley Richardson, Daniel Hasegawa
- Field Trials - Spence
- Greenhouse inoculations
- Screening
- Pythium damping off and Pythium wilt (P. uncinulatum)

INSV Inoculations on Spinach

Control

Inoculated

AgDia Test Strips



INSV on Spinach

- Screening Commercial Varieties
- Inoculations and Field Tests
- *Pythium uncinulatum* root colonization and damage
- *P. uncinulatum* impact on INSV severity?
- Predisposition?

Damping off Disease Pressure Increasing

- More intensive production
- Less rotation
- Higher planting densities
- Reduced chemical control options
- Limited highly effective organic options
- Increased soil temperatures
- Seed prices are increasing

Overview of Damping off of Spinach

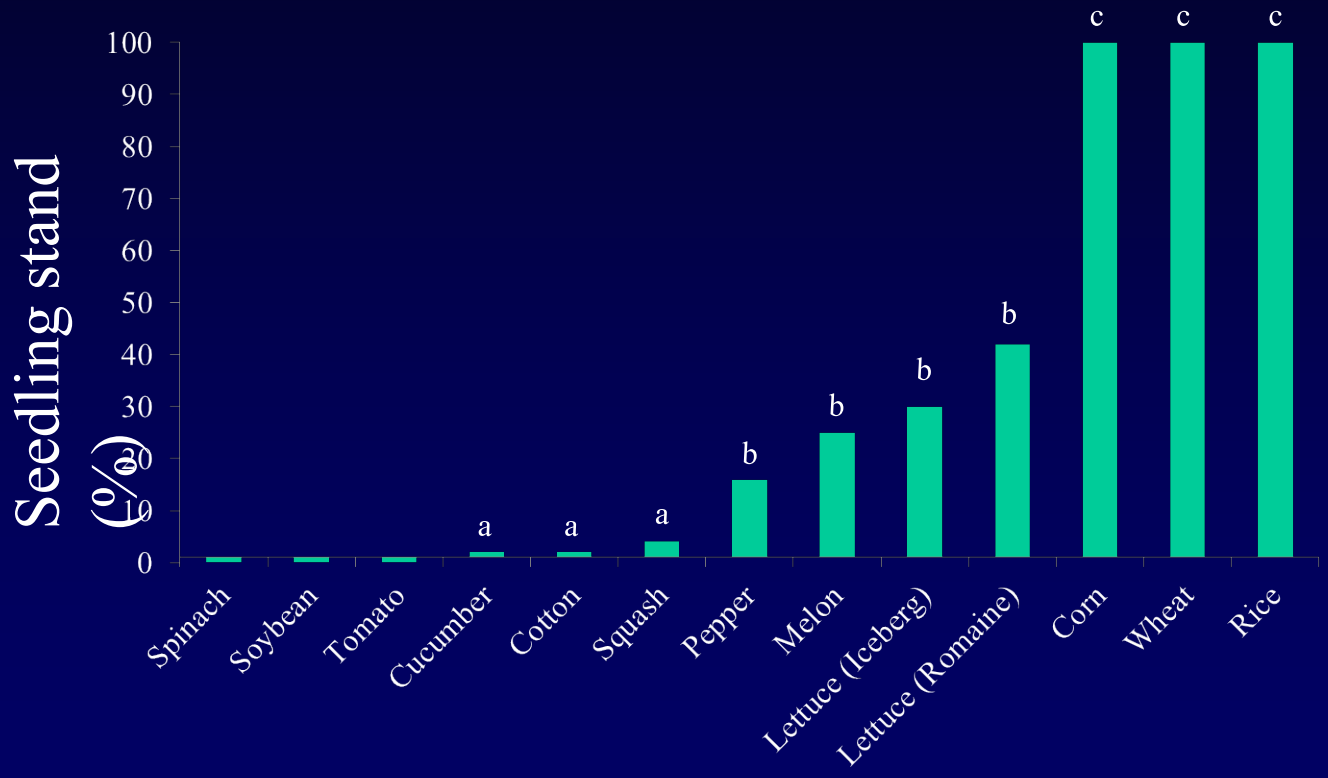
- Pathogens and host
  - *Pythium* species
  - *Fusarium oxysporum* f. sp. *spinaciae*
  - *Rhizoctonia solani*
  - *Phytophthora* species
- Temperature (soil/air)
- Seedling vigor (emergence: escape versus resistance)
- Reduced crop rotation and increased plant densities
- Soil and chemical factors
- Herbicides
- Soil compaction

Web blight symptoms in Yuma, Arizona

Water soaked foliage, rapid collapse of young plants, with evidence of white cottony mycelia

Web blight symptoms of spinach 3 locations in Arizona

Damping-off caused by *P. aphanidermatum*



Summary of Damping Off of Spinach

Pathogen	Temperature optimum	Pre-emergence	Early Post-emergence (< 7-10 days)	Late Post-emergence (>7-10 days)	Root rot
P. ultimum	Low	+++	++	-	-
P. aphanidermatum	High	+++	++	-	-
P. dissotocum	Low-High	++	++	-	
P. uncinulatum	Low-High	?	?	?	?
F. oxysporum f. sp. spinaciae	High	-	+	+++	-
Rhizoctonia solani	High	-	+	++	+
Phytophthora spp.	Low	-	-	++	+

Summary of Damping Off of Spinach

Pathogen	Temperature optimum	Pre-emergence	Early Post-emergence (< 7-10 days)	Late Post-emergence (>7-10 days)	Root rot
P. ultimum	Low	+++	++	-	-
P. aphanidermatum	High	+++	++	-	-
P. dissotocum	Low-High	++	++	-	
P. uncinulatum	Low-High	?	?	?	?
F. oxysporum f. sp. spinaciae	High	-	+	+++	-
Rhizoctonia solani	High	-	+	++	+
Phytophthora spp.	Low	-	-	++	+

P. uncinulatum on spinach

Isolate	Species	Mean (% stand)
Control		85.0 a[y]
JP5	P. uncinulatum	80.0 a
JP4	P. uncinulatum	80.0 a
JP7	P. uncinulatum	80.0 a
JP2	P. uncinulatum	75.0 a
JP3	P. uncinulatum	60.0 b
JP6	P. uncinulatum	45.0 c
Sk.P2.6A	P. uncinulatum	45.0 c
AZ3a	P. aphanidermatum	1.5 d

Plug Pathogenicity test Result 10/28/2028

Table 1: Average stand count of viroflay seeds (20 seeds per plot) for 8 treatments infested with 20 colony plugs across 5 replications, recorded at 5, 7, 10, and 14 days post-inoculation (dpi).

Number	Treatment	Tissue Type	Avg. stand count			
			5 dpi*	7 dpi	10 dpi	14 dpi
1	Control (PDA Plugs)		10.8	11.6	12.8	12.8
2	SKP92 (*Pythium uncinulatum*)	-	8.0	10	10.6	11.2
3	PS06 (*Pythium* sp.)	Symptomatic Psyllium	5.2	5.2	5.0	4.8
4	EF11(*P. dissotocum*)	Spinach	4.6	4.0	4.4	3.8
5	PS28 (*Pythium* sp.)	Psyllium	3.0	4.0	4.2	4.0
6	PS19 (*Pythium* sp.)	Symptomatic Psyllium	3.4	3.4	3.6	3.8
7	PS09 (*Pythium* sp.)	-	1.8	1.8	1.8	1.8
8	EF15 (*P. dissotocum*)	Spinach	1.8	1.4	1.4	1.4

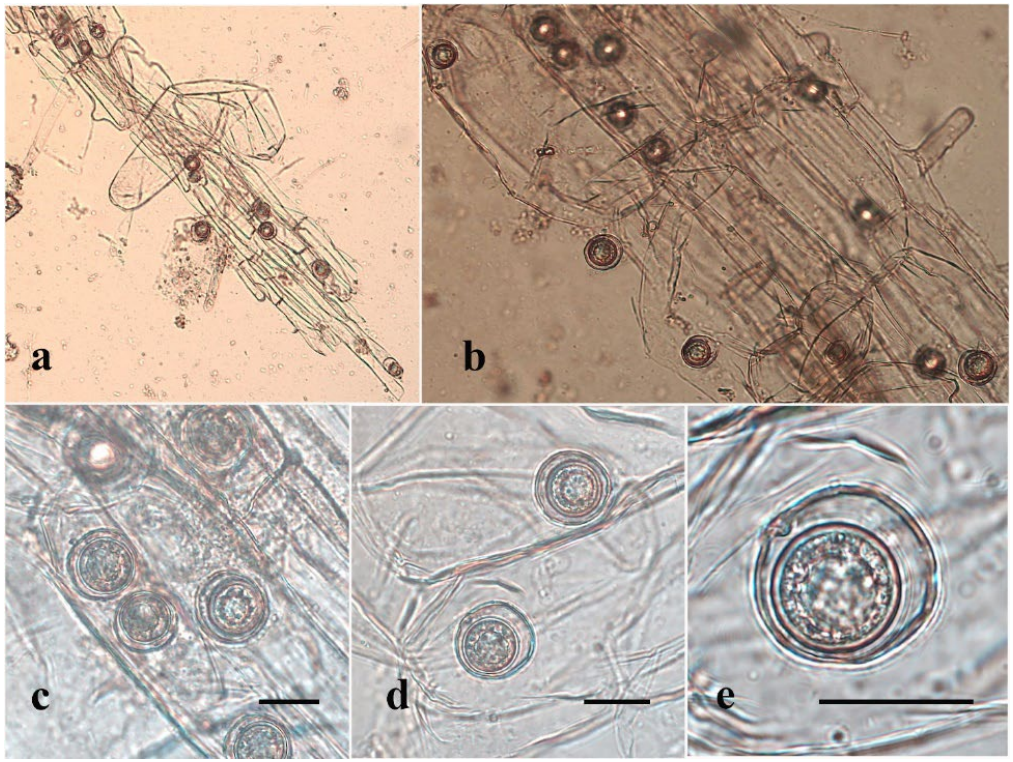


Figure 1. Morphology of *Pythium* sp. (a-b) Mature oogonia

Survey of major leaf spot pathogens and new pathogens

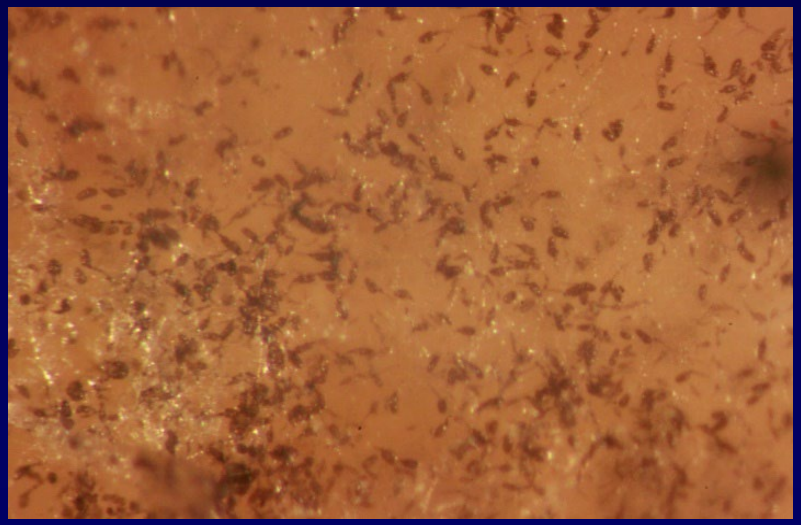
Pathogen	Samples positive for that pathogen/total number of samples examined	Incidence (%)
Colletotrichum spinaciae	28/63	44
Stemphylium vesicarium and *S. beticola*	39/63	62
Cercospora beticola	5/63	8
*Colletotrichum coccodes** and *C. truncatum**	4/63	6
*Myrothecium verrucaria**	2/63	3

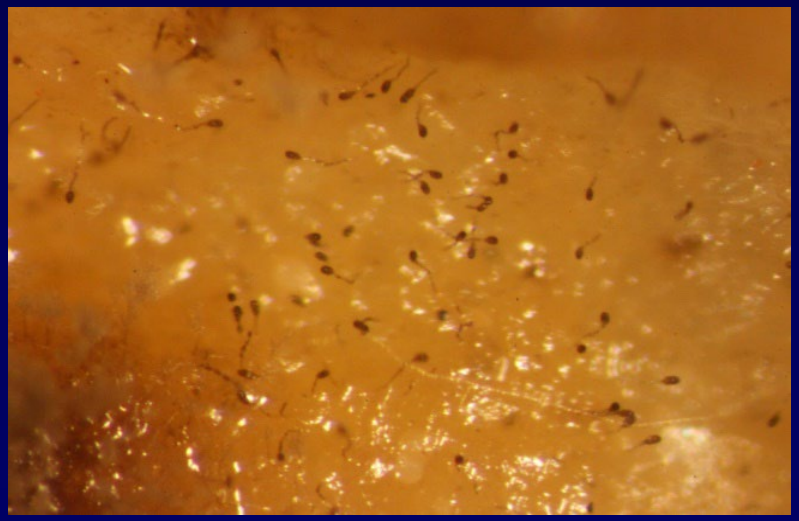
All the fungal pathogens were identified based on morphology and DNA sequence analysis

*: New diseases on spinach.

Symptoms of Stemphylium leaf spots

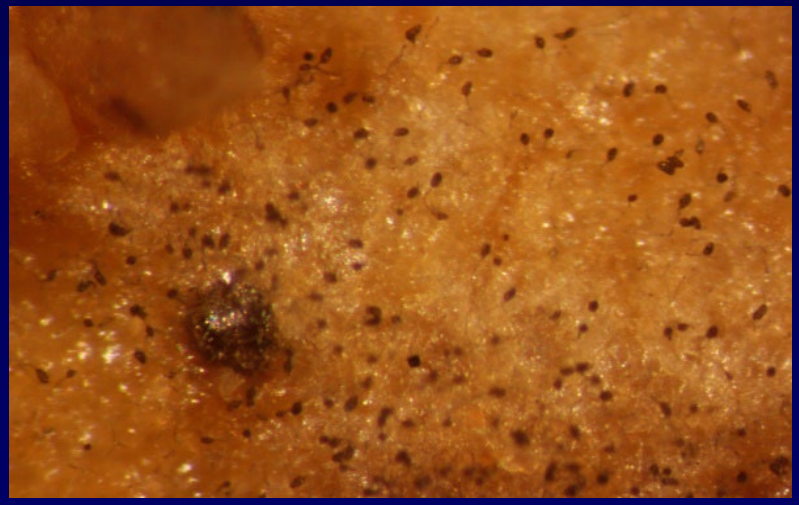
Stemphylium leaf spot (*S. vesicarium*)





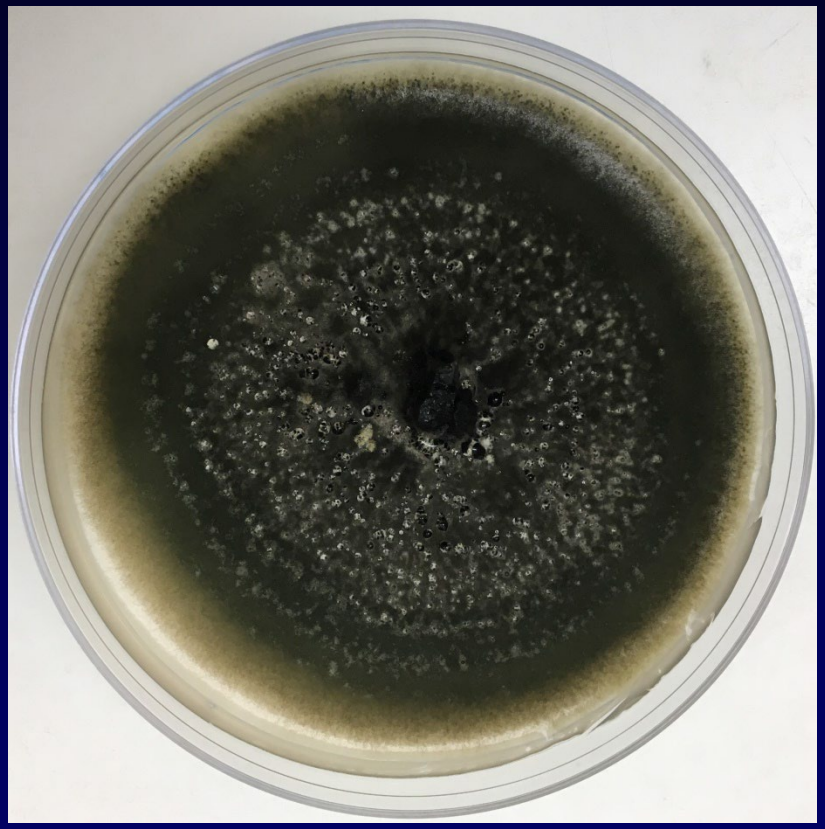
Conidia and conidiophores can be observed on older lesions on spinach leaves

Stemphylium leaf spot (*S. beticola*)

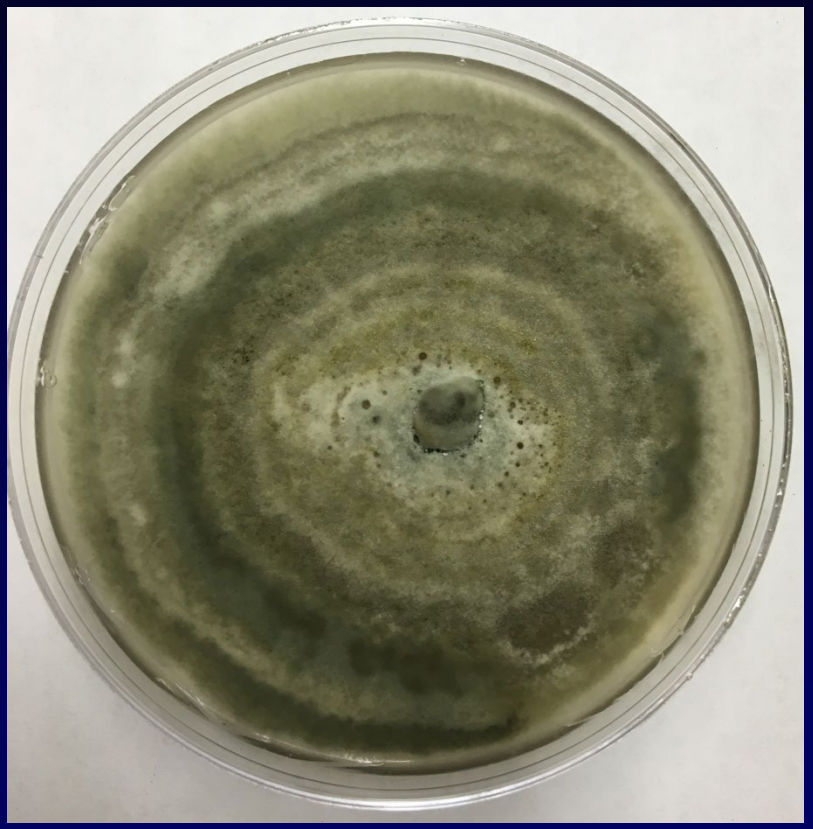


Conidia and conidiophores can be observed on older lesions on spinach leaves

Colony morphology of *Stemphylium* on PDA 14 days



Stemphylium vesicarium



Stemphylium beticola

Morphology of *Stemphylium* spp.

Stemphylium vesicarium

Stemphylium beticola

Test-1. Resistance screen to *Stemphylium* spp. on commercial spinach cultivars

Variety	Mean severity (Sb-3-St033)	Standard error	Mean severity (Sb-6-St257)	Standard error
	(*S. vesicarium*)		(*S. beticola*)	
Shelby	4.0 a	0.1	4.0 a[b]	0.2
Flamingo	4.0 a	0.1	1.1 fe	0.2
Playtopus	4.0 a	0.1	1.6 dc	0.2
Viroflay	3.6 b	0.1	4.0 a	0.2
El Prado	2.7 c	0.1	1.9 c	0.2
Carmel	1.3 d	0.1	4.0 a	0.2
Meerkat	1.1 ed	0.1	1.0fe	0.2
Pigeon	1.0 edf	0.1	1.0 fe	0.2
Sioux	0.9 egf	0.1	0.8 fg	0.2
SV2146	0.8 egf	0.1	1.0 fe	0.2
PV1446	0.7 gf	0.1	1.2 de	0.2
Hydrus	0.6 g	0.1	0.6 g	0.2
Viroflay(Water Control)	0.0 h	0.1	0.0 h	0.2
LSD	0.37		0.41	

Disease severity is from 0 to 4.

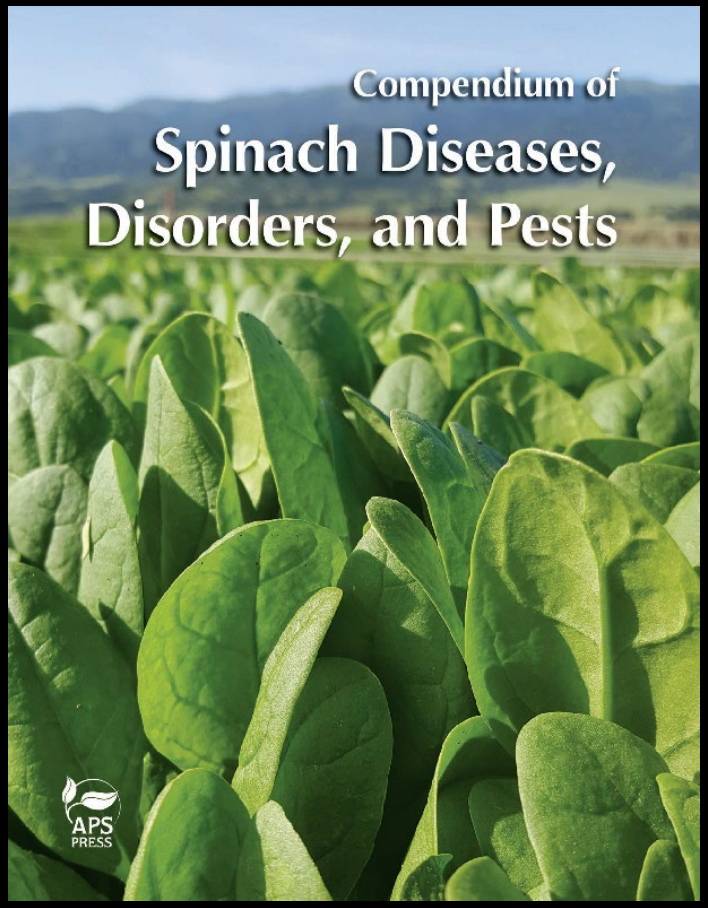
Different letters indicate they were significantly different at $P < 0.05$.

International Spinach Conference

- 2025? Salinas, California (October)
- 2023 Melbourne, Australia
- 2018 Murcia, Spain
- 2016 San Antonio, Texas
- 2015 Yuma, Arizona
- 2013 Guangzhou, China
- 2012 San Antonio, Texas
- 2011 Amsterdam, Netherlands
- 2009 Fayetteville, Arkansas
- 2007 Salinas, California
- 2006 La Conner, Washington
- 2000 San Antonio, Texas

Compendium of Spinach Diseases, Pests, and Disorders

- Jim, Lindsey, Bev, Tim, Maria
- Diseases, Insects, Weeds
- Abiotic disorders
- Crop and Seed Production
- Portions are under review
- Finalizing several sections
- Finish line – December 2024



CALIFORNIA LEAFY GREENS
RESEARCH PROGRAM

Thank you

UofA
DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System