Lettuce breeding for disease resistance

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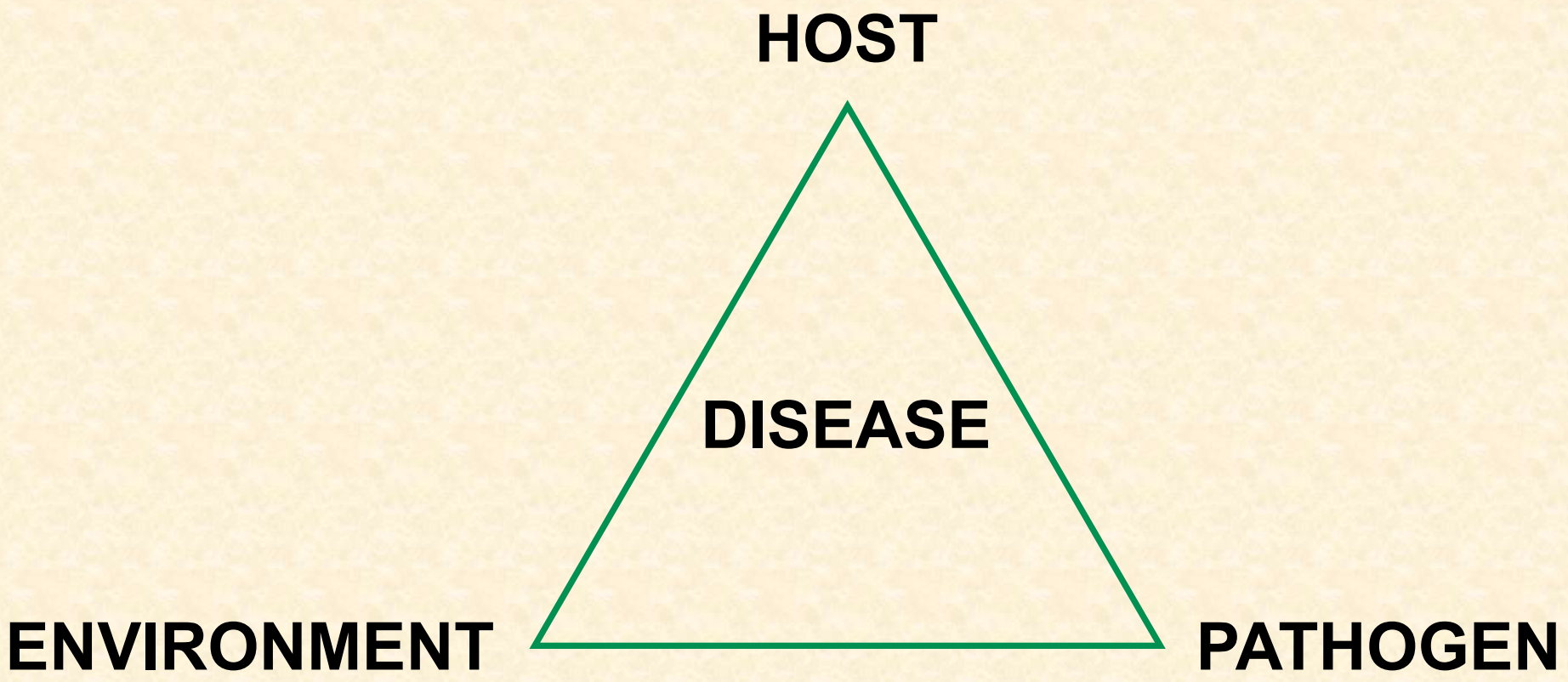
2024 Pest Management meeting

Role of breeding in the disease triangle

- **Choose hosts (varieties) that don't get disease or have reduced symptoms**
- **Choose hosts that can adapt to changes in environment and pathogen to maintain resistance**



Language and definitions

- **Susceptible- plant gets infected and shows significant symptoms**
- **Resistant- plant maintains marketability**
  - **Immune- plant doesn’t get infected, doesn’t show symptoms**
  - **Tolerant (partial or intermediate resistance)- plant gets infected, doesn’t show symptoms (or reduced symptoms)**

Types of resistance

- Qualitative-
  - Single, large effect, gene gives resistance
  - Plant either has disease symptoms or does not
  - Resistant plants do not have symptoms, susceptible plants do
  - Often not durable
- Quantitative-
  - Many, small effect, genes are required
  - Plant can have a wide range of symptom severity
  - Resistant plants have reduced symptoms compared to susceptible plants
  - Often more durable

Mechanisms of resistance

- Knowing the mechanism directs management
- Resistance is any mechanism that results in a marketable crop:
  - Thrips can't or won't feed on the lettuce
  - Thrips can or will feed on the lettuce, but can't transmit the virus
  - Thrips feed and transmit INSV, but the virus can't spread throughout the plant
  - Thrips feed, transmit INSV, the virus spreads, but the plant doesn't show disease symptoms
  - Thrips feed, transmit INSV, the virus spreads, the plant shows symptoms, but low enough incidence or severity to harvest the crop

USDA Agricultural Research Service

- What is the USDA’s role in breeding?
- Deliver cutting-edge, scientific tools and innovative solutions for US growers, industry, and communities
- Industry has asked us to serve as pre-breeders
- Develop strategic plans to meet stakeholders' needs and support USDA's mission
- Scientists frequently collaborate with universities, companies, other organizations, and other countries
- We share research results at conferences, field days, grower meetings, publications

Review of INSV breeding efforts

- **USDA INSV resistance breeding- a case study**
- **Minor INSV in Monterey county prior to 2015**
- **In 2018, saw a significant increase in INSV in commercial and research fields**
- **Implemented a field evaluation protocol in 2020**

INSV severity rating

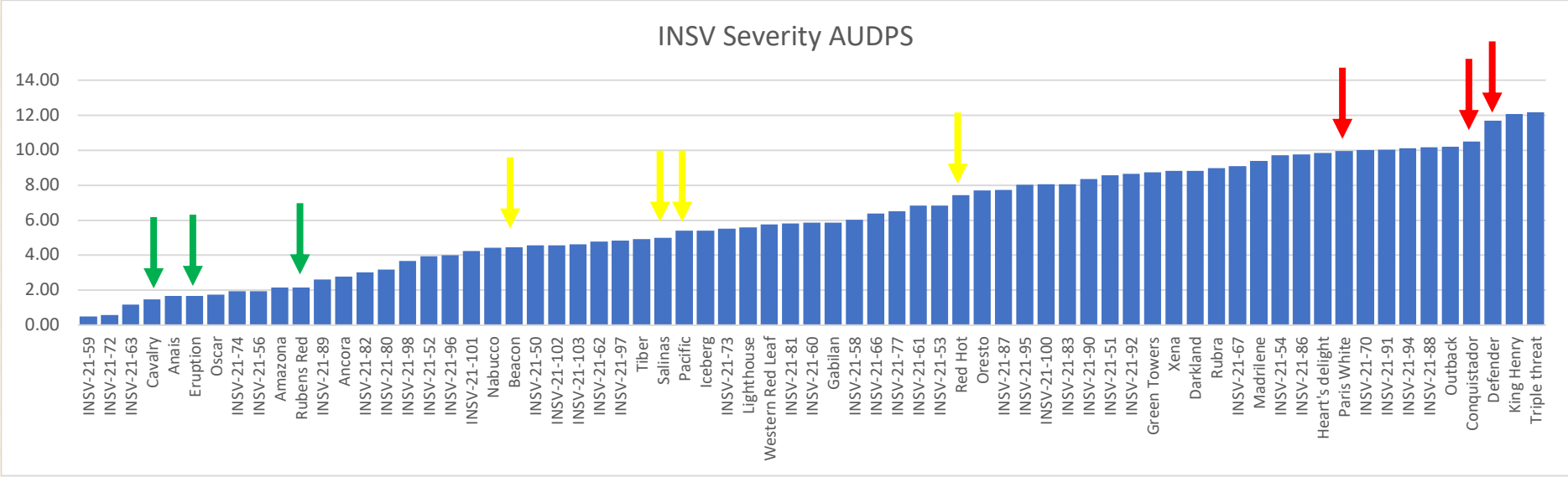
- **Rated each plant for INSV severity (0-5) at 6, 7, 8, and 9 weeks after planting**

Hasegawa and Del Pozo-Valdivia, 2023

	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10	Date	MEAN
Week 1	0	1	0	0	0	0	0	0	0	1	9/28	.2
Week 2	1	2	1	1	1	0	0	1	0	1	10/5	.8
Week 3	2	2	2	2	2	1	1	2	1	1	10/1	1.6
Week 4	2	2	2	2	2	2	2	2	2	2	10/1	2
Week 5	2	2	2	3	2	3	2	2	2	4	10/2	2.4

Germplasm evaluation

- **2021 and 2022, June and August plantings at Spence Farm**
- **Tested breeding lines, commercial varieties, and wild material of any color and head type**
- **Selected material consistently resistant, intermediate, or susceptible**



Dissecting mechanisms of resistance

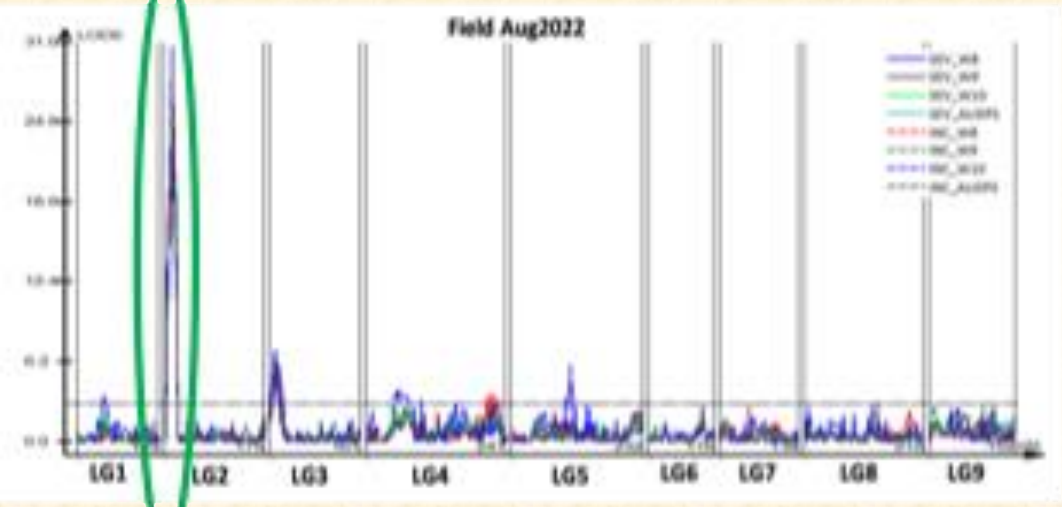
- **Selected material tested in the greenhouse and growth room**
- **INSV severity AUDPS in the field, greenhouse, and virus only**
- **Number of adult (preference) and immature (reproduction) thrips**

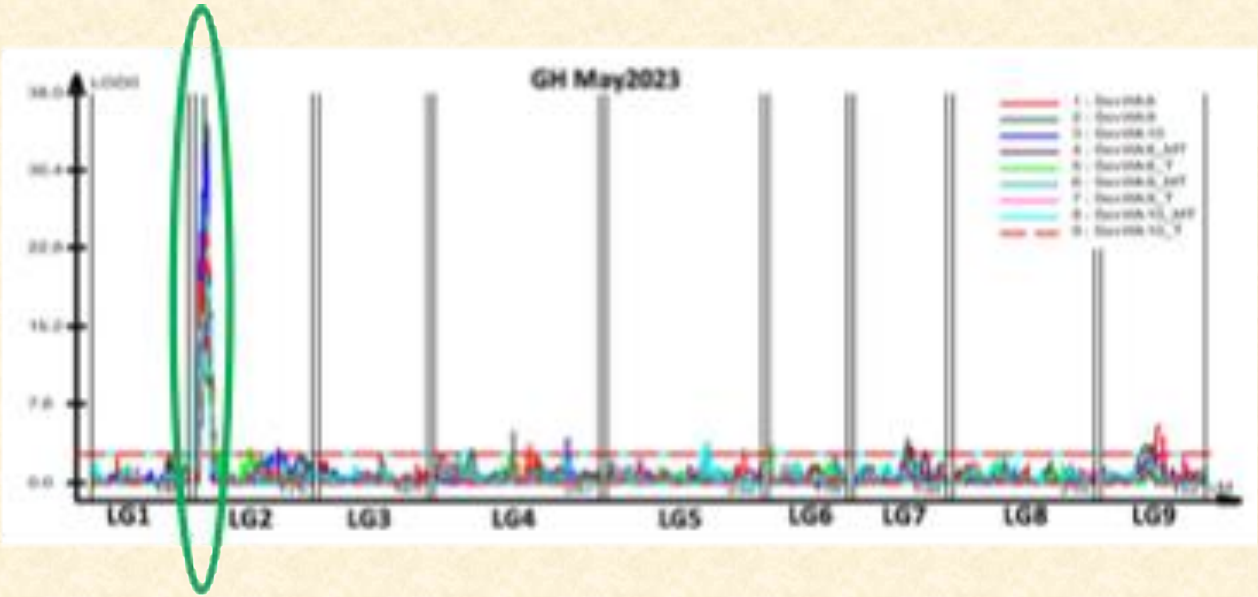
RANK	Field INSV severity AUDPS	GH INSV severity AUDPS	Virus only severity AUDPS	Thrips adult preference	Thrips reproduction
1	Eruption (1.3)	Cavalry (10.13)	Ruben's Red (4)	Eruption (3.29)	BL280 (RH15-0973) (21.25)
2	Cavalry (2.1)	Ruben's Red (10.38)	BL280 (RH15-0973) (5.5)	Cavalry (4.43)	Cavalry (26.71)
3	Ruben's Red (2.7)	Eruption (10.38)	Salinas (5.92)	BL280 (RH15-0973) (5.00)	BL288 (RH15-0981) (33.57)
4	Beacon (4.7)	Flashy Troutback (10.38)	Pacific (6.33)	BL288 (RH15-0981) (6.00)	Flashy Troutback (43.80)
5	Salinas (5.1)	BL288 (RH15-0981) (11.75)	BL288 (RH15-0981) (6.75)	Ruben's Red (6.29)	Eruption (44.29)
6	Pacific (5.9)	Beacon (12)	Eruption (7)	Red Hot (7.86)	Ruben's Red (60.14)
7	Red Hot (8.9)	Red Hot (12.25)	Conquistador (7)	Defender (8.14)	Salinas (61.14)
8	BL280 (RH15-0973) (9.4)	Salinas (12.5)	Flashy Troutback (8.42)	Salinas (8.14)	Defender (62.43)
9	BL288 (RH15-0981) (9.8)	Defender (13.13)	Beacon (9.42)	Conquistador (8.43)	Red Hot (67.14)
10	White Paris (11)	BL280 (RH15-0973) (13.63)	Cavalry (10.42)	Flashy Troutback (9.80)	White Paris (78.14)
11	Flashy Troutback (12)	Pacific (13.75)	Red Hot (13.58)	Pacific (10.00)	Pacific (87.29)
12	Conquistador (12.2)	Conquistador (15)	Defender (14.08)	White Paris (10.00)	Conquistador (91.43)
13	Defender (13.6)	White Paris (19.25)	White Paris (15.83)	Beacon (13.29)	Beacon (103.71)

	Virus	Thrips
Cavalry	Susceptible	Non-preferred host
Ruben's Red	Resistant	Preferred host
Eruption	Intermediate	Intermediate host

Genetic location of resistance

- Learn where the genes are and find linked markers
- MAS allows rapid introgression of resistance
- Pair field and greenhouse mapping population data with genetic linkage map
- Highly significant QTL on linkage group 2
- Developing MAS assay



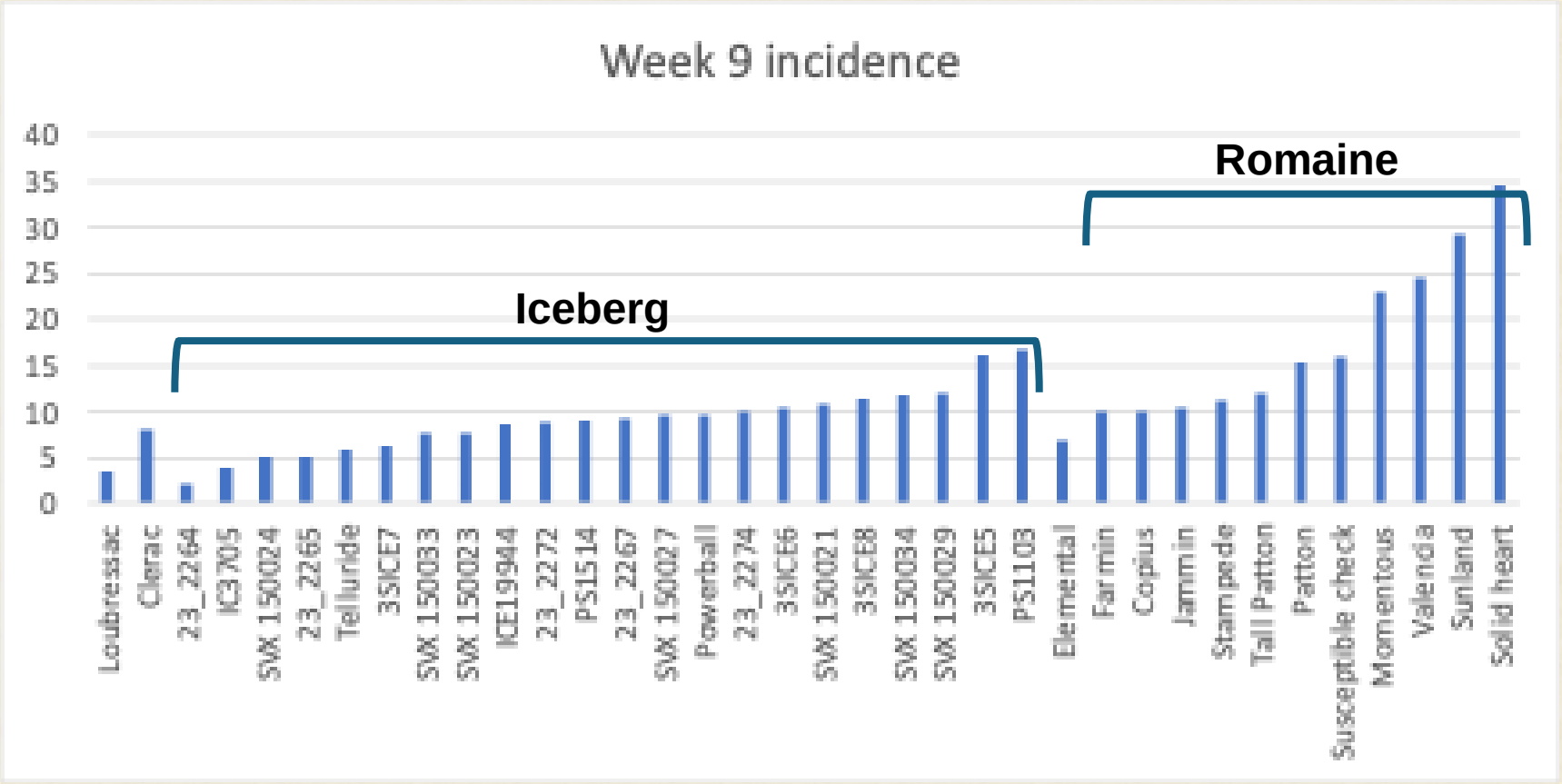


What about solutions today?

- **Breeding takes time!**
- **Evaluate popular commercial varieties available NOW**
- **2022 - 2024 Pythium/INSV variety trials**
- **Results direct breeding efforts**
- **INSV and Pythium incidence**
- **Due to low 2023 pressure, added a greenhouse test in 2024**

Pythium/INSV variety trial

- **2024 has higher INSV pressure than 2023, but still low (average 11.5% incidence)**
- **Romaine susceptible check, 15.9%**



Field vs greenhouse

- High pressure greenhouse vs low pressure field
- Good correlation
- Low pressure can give the incorrect impression of resistance
- Tolerant varieties can still be a valuable management tool at low pressure

				Field	GH
Entry	Cultivar	Company	Type	Field incidence (%)	GH Severity (0-5)
4	Loubressac	Seminis	Green leaf	3.54	1.83
3	Clerac	Seminis	Green leaf	8.15	2.08
13	IC3705	Rijk Zwaan	Iceberg	3.97	0.75
25	23_2264	Sakata	Iceberg	2.27	1.08
30	SVX 150021	SVS	Iceberg	10.83	1.08
26	23_2265	Sakata	Iceberg	5.21	1.33
6	PS1514	Pinnacle	Iceberg	9.15	1.42
27	23_2267	Sakata	Iceberg	9.23	1.42
14	Telluride	Enza Zaden	Iceberg	5.99	1.5
23	3SICE7	3 Star	Iceberg	6.22	1.5
29	23_2274	Sakata	Iceberg	10.02	1.58
5	PS1103	Pinnacle	Iceberg	16.7	1.75
9	ICE19944	Vilmorin-Mikado	Iceberg	8.7	1.92
35	SVX 150033	SVS	Iceberg	7.67	1.92
32	SVX 150024	SVS	Iceberg	5.11	2.08
28	23_2272	Sakata	Iceberg	8.8	2.33
24	3SICE8	3 Star	Iceberg	11.37	2.42
31	SVX 150023	SVS	Iceberg	7.69	2.67
2	Powerball	Seminis	Iceberg	9.73	2.83
22	3SICE6	3 Star	Iceberg	10.47	3
33	SVX 150027	SVS	Iceberg	9.71	3.17
34	SVX 150029	SVS	Iceberg	12.03	3.25
21	3SICE5	3 Star	Iceberg	16.18	3.33
36	SVX 150034	SVS	Iceberg	11.87	3.33
20	Elemental	Nunhems	Multi gem	6.9	1.92
8	Patton	Greengo	Romaine	15.35	0.83
7	Tall Patton	Greengo	Romaine	12.01	0.92
11	Jammin	Rijk Zwaan	Romaine	10.51	1.83
18	Copius	Nunhems	Romaine	10.06	1.83
10	Stampede	Syngenta	Romaine	11.17	2
12	Farmin	Rijk Zwaan	Romaine	9.98	2
15	Valencia	CVS	Romaine	24.53	2.17
16	Sunland	CVS	Romaine	29.2	2.17
19	Momentous	Nunhems	Romaine	23.07	2.33
17	Solid heart	CVS	Romaine	34.63	2.58

Fusarium characterization

- Fol321
- Fol621

Recovered from infected lettuce of two different fields in Salinas

- Fol621s

Single spore culture of Fol621

- VSP-0916
- VSP-0794

Received from Alex Putman, UC Riverside

Pathogenicity test: Root dip inoculation

Grow seedlings in pasteurized sand

14 to 18 days old seedlings

Trim root ~ 5 mm

Dip root for 20 min (Treatments: FOL isolates and Mock)

Transplant in cups filled with pasteurized potting soil/sand mix

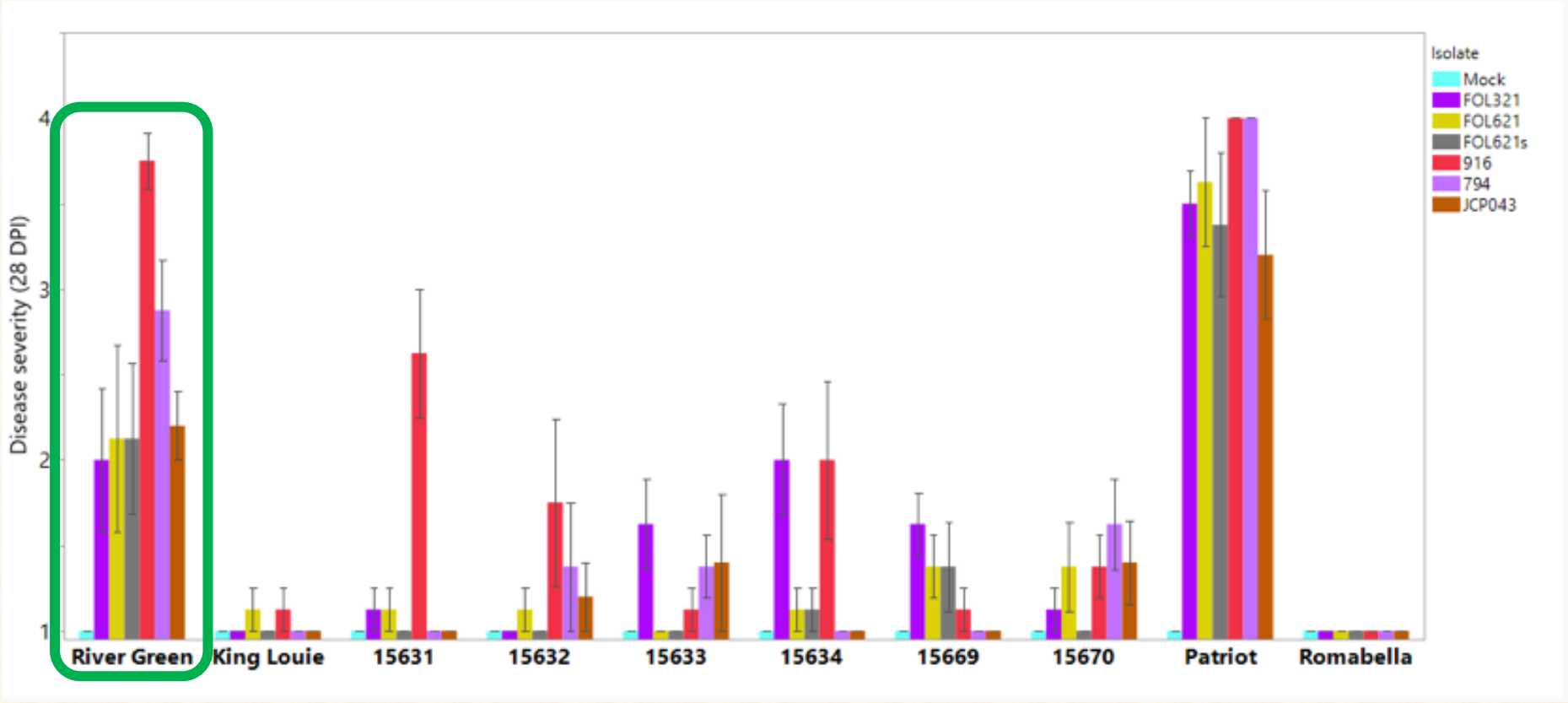
Greenhouse / growth room (25 ℃ / 16 h photoperiod)

Compare to reported races

Differential	Fol: 1	Fol: 2	Fol: 3	Fol: 4		321	621	621s	794	916
						Race 1	Variant		Race 1	Variant
Patriot	S	S	S	IR		S	S	S	S	S
Banchu Red Fire	S	HR	S	IR		S	IR	IR	S	IR
Costa Rica No. 4	HR	S	S	S		HR	HR	HR	HR	S
Romabella	HR	HR	S	IR		HR	HR	HR	HR	IR
Gisela*	S	S	S	S		S	S	S	S	S
Ballerina*	S	S	S	IR		S	S	S	S	S
Lomeria*	S	HR	HR	HR		S	IR	IR	S	S
Palmos*	HR	S	IR	HR		HR	HR	HR	HR	IR

Germplasm evaluation

- **Evaluating race 1-resistant material under race 1 and variants.**
- **916 is race 1-breaking.**
- **USDA released lines holding up.**



Fusarium industry working group

- **The changing FOL populations in our growing regions pose a serious threat for growers and a challenge for breeders.**
- **Ring Test- a public and private collaboration to:**
  - **Run a multi-lab test to compare FOL isolates on a panel of differential varieties with different levels of resistance.**
  - **If results support it, officially name Race 5.**
  - **Harmonize a protocol for evaluating germplasm and determining resistance to the novel race.**

Fusarium publication

Plant Pathology An International Journal edited by the British Society for Plant Pathology

WILEY

ORIGINAL ARTICLE

Detection of novel pathogenic variants of *Fusarium oxysporum* f. sp. *lactucae* in California

Santosh Nayak[1] | Kelley L. Richardson[1] | Alexander I. Putman[2] | Nicholas R. LeBlanc[1] | Frank N. Martin[1] | Ningxiao Li[1] | James D. McCreight[1]

INSV Publication

Euphytica (2024) 220:33
https://doi.org/10.1007/s10681-023-03285-z

RESEARCH

Evaluation of lettuce germplasm for resistance to impatiens necrotic spot virus

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