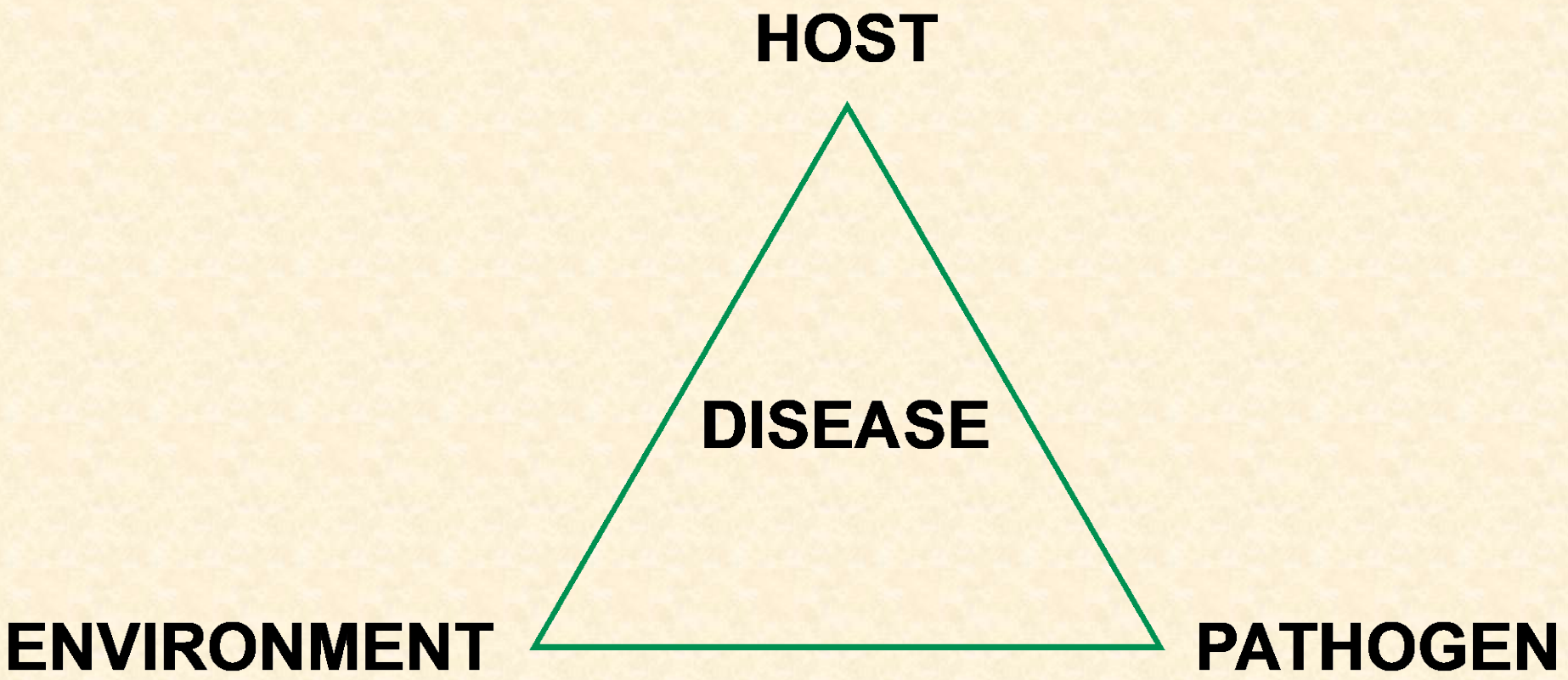
Lettuce breeding for disease resistance

Kelley L. Richardson

2025 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 shows reduced symptoms)

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
- Identify new sources of disease resistance
- 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

INSV Publication

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

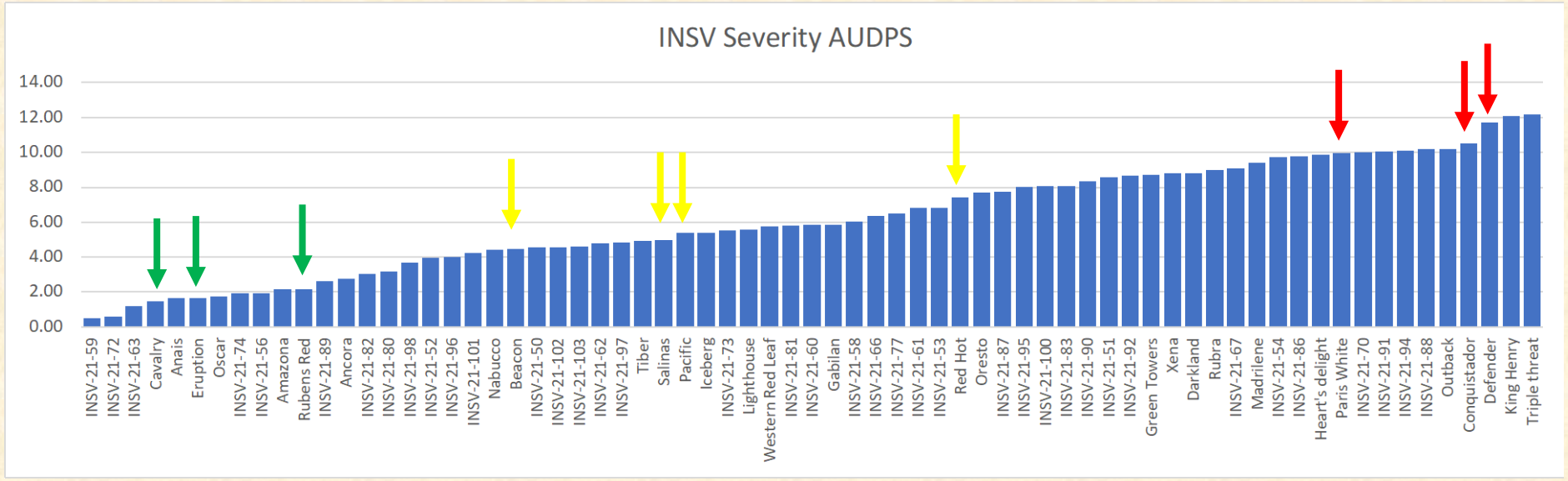
RESEARCH

Evaluation of lettuce germplasm for resistance to impatiens necrotic spot virus

Kelley L. Richardson · Santosh Nayak · Daniel K. Hasegawa · Renée L. Eriksen

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

INSV Publication

Theoretical and Applied Genetics (2025) 138:312
https://doi.org/10.1007/s00122-025-05058-9

ORIGINAL ARTICLE

Check for updates

A major and stable QTL confers impatiens necrotic spot virus resistance in lettuce cv. Eruption

Santosh Nayak[1] · Kelley L. Richardson[1] · Renée L. Eriksen[1] · Daniel K. Hasegawa[1] · William M. Wintermantel[1] · Manoj Sapkota[2] · Xuemei Tang[2] · Shufen Chen[2] · Meng Lin[2] · Dongyan Zhao[2] · Craig T. Beil[2] · Moira J. Sheehan[2] · Ivan Simko[1]

What about solutions today?

- Breeding takes time!
- Evaluate popular commercial varieties available NOW
- 2022 - 2025 Pythium/INSV variety trials
- Results direct breeding efforts and variety selection
- INSV and Pythium incidence
- Due to low 2023 pressure, added a greenhouse test in 2024

Pythium/INSV variety trial

- 2025 (average 45.9% incidence) was higher INSV pressure than 2024 (11.5%)
- Romaine susceptible check, 83.6% (15.9% in 2024)

Field vs greenhouse

- High pressure greenhouse vs moderate 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

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]

Received infected lettuce

- August 2021 received *Fusarium* infected plants
- Increase in incidence and severity
- Previously resistant varieties showing disease and susceptible varieties showing resistance

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

Compare to reported races

Variant Variant

Differential	Fol: 1	Fol: 2	Fol: 3	Fol: 4		321	621	621s	794	916
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

VSP-0916- New race nominee?

- Additional variants found in multiple locations and years
- Variation in virulence amongst isolates, VSP-0916 most severe

VSP-0916- New race nominee?

- **Breaking resistant commercial varieties**

Powerball **Calmer**

Fusarium ring test

- The changing 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 differential varieties following ISF IBEB FOL:4 report guidelines
  - Harmonize a protocol for evaluating germplasm and determining resistance to the novel race
  - If results support it, nominate a new race

Ring test participants

- 8 US public and private groups
- 9 international participants

Isolates

- UPOV lettuce guidelines (May 2024) with modifications and options
  - Full set

  - Reduced set

Entries

- **Both named and unnamed entries**

Pathogenicity test: Root dip inoculation

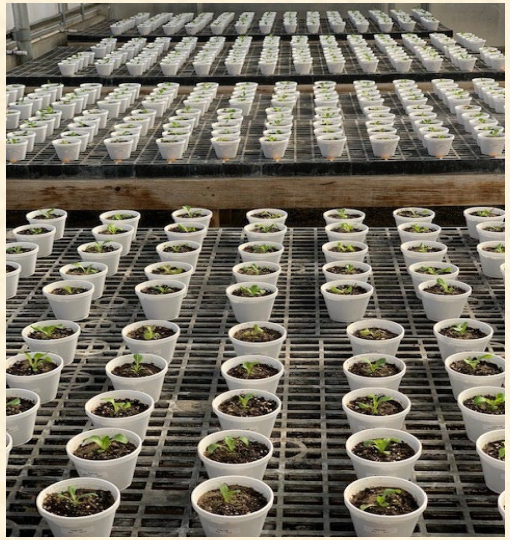
Grow seedlings in pasteurized sand

14 to 18 days old seedlings

Trim root ~ 5 mm

Dip root for 10 min (Treatments: FOL isolates and Mock)

Transplant in cups filled with pasteurized potting soil/sand mix



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

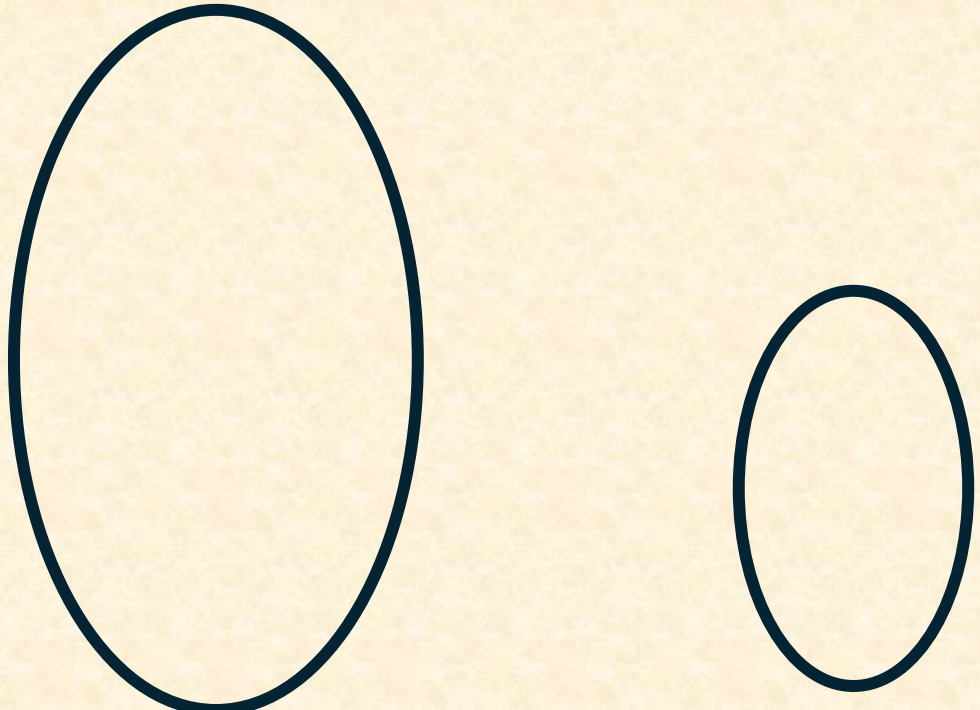
Disease rating

- Weekly for 28 days after inoculation
- 28 dpi, cut roots of class 0 and 1 plants and check for discoloration

Preliminary analysis

Discussion of results

- High uniformity of results across labs, Palmos showed more variation due to differing methods amongst labs
- Variant isolates are clearly different from race 1, especially in Costa Rica 4 and Palmos



What's next?

- We presented results to the International Lettuce Fusarium Evaluation Board
- Initiated global discussion on nominating new races and running pathogenicity assays and germplasm evaluation
- Planning comparison of VSP-0916 and European variant isolates
- Meet with ILFEB in April 2026 for next steps
- Evaluating germplasm for resistance to race 1 and VSP-0916

Fusarium publication

Received: 30 September 2024 | Accepted: 23 December 2024

DOI: 10.1002/plr2.20423

Journal of Plant Registrations

REGISTRATION

Germplasm

Registration of six lettuce breeding lines with resistance to Fusarium wilt race 1

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