Lettuce Breeding for INSV Resistance

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Pest Management Meeting

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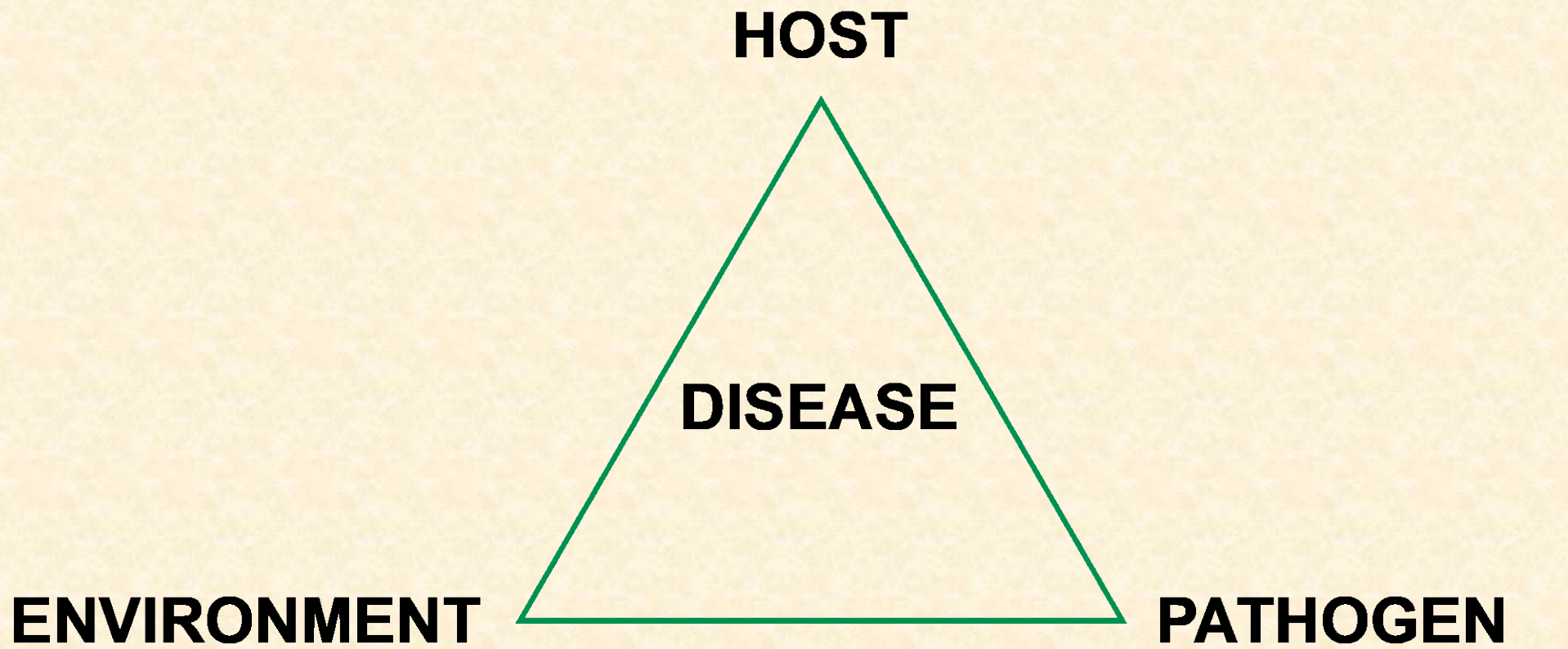
Outline

- Review of disease breeding
- Genetics definitions
- Role of USDA
- A case study of breeding for INSV resistance
- Solutions for today
- Co-infection with other diseases
- Continuing USDA breeding goals

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 symptoms**
- **Resistant-**
  - **Immune- plant doesn't get infected and doesn't show symptoms**
  - **Tolerant- plant gets infected, but doesn't show 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 INSV 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

Flag plots

- 10 plants per seedline flagged for weekly evaluation

INSV severity rating

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

	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

D. Hasegawa

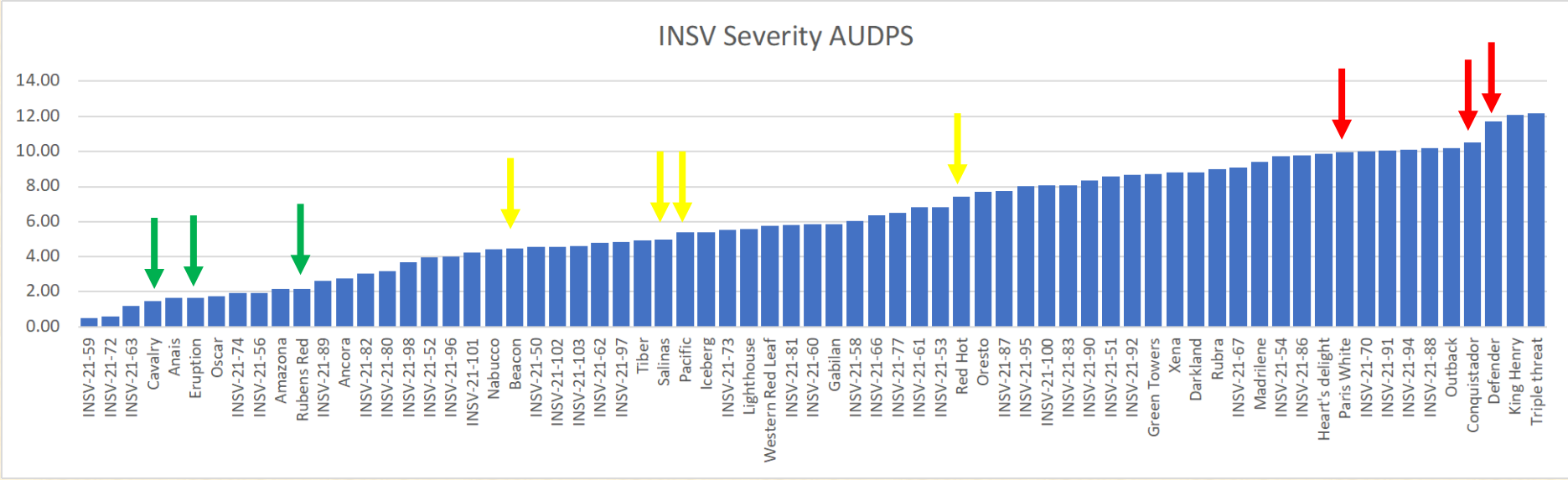
Severity vs incidence

- **Incidence- percent of non-marketable plants**

	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10	Incidence
Week 1	0	1	0	0	0	0	0	0	0	1	0%
Week 2	1	2	1	1	1	0	0	1	0	1	10%
Week 3	2	2	2	2	2	1	1	2	1	1	60%
Week 4	2	2	2	2	2	2	2	2	2	2	100%
Week 5	2	2	2	3	2	3	2	2	2	4	100%

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

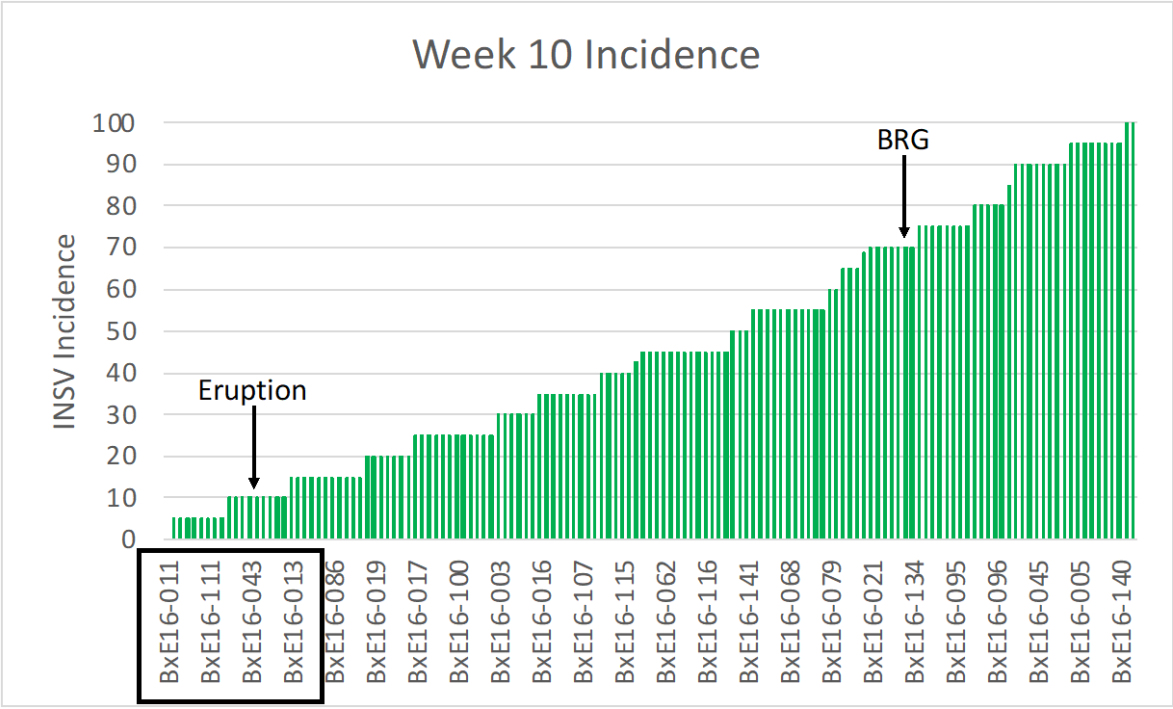
- **Selected material tested in the greenhouse and growth room**
- **INSV severity AUDPS in the field, greenhouse, and virus only**
- **Number of adult (preference) and immature (reproduction) thrips**

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

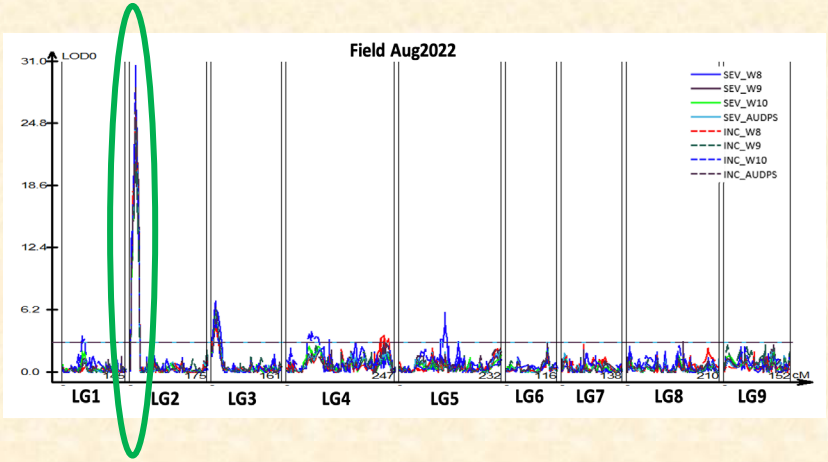
- **Learn where the genes are and find linked markers**
- **MAS allows rapid introgression of resistance**
- **Mapping population, Eruption (resistant parent), and BRG (susceptible parent) (August 2022, RCBD, 3 reps)**

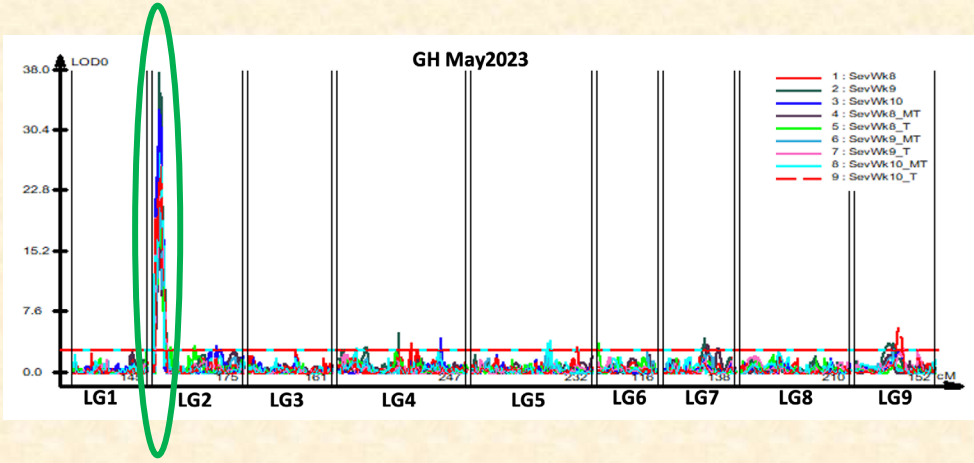


- **18 lines with less than 10% incidence**
- **9 lines lower than Eruption**
- **Future germplasm release**
- **Genetic tools**

Linkage analysis for MAS

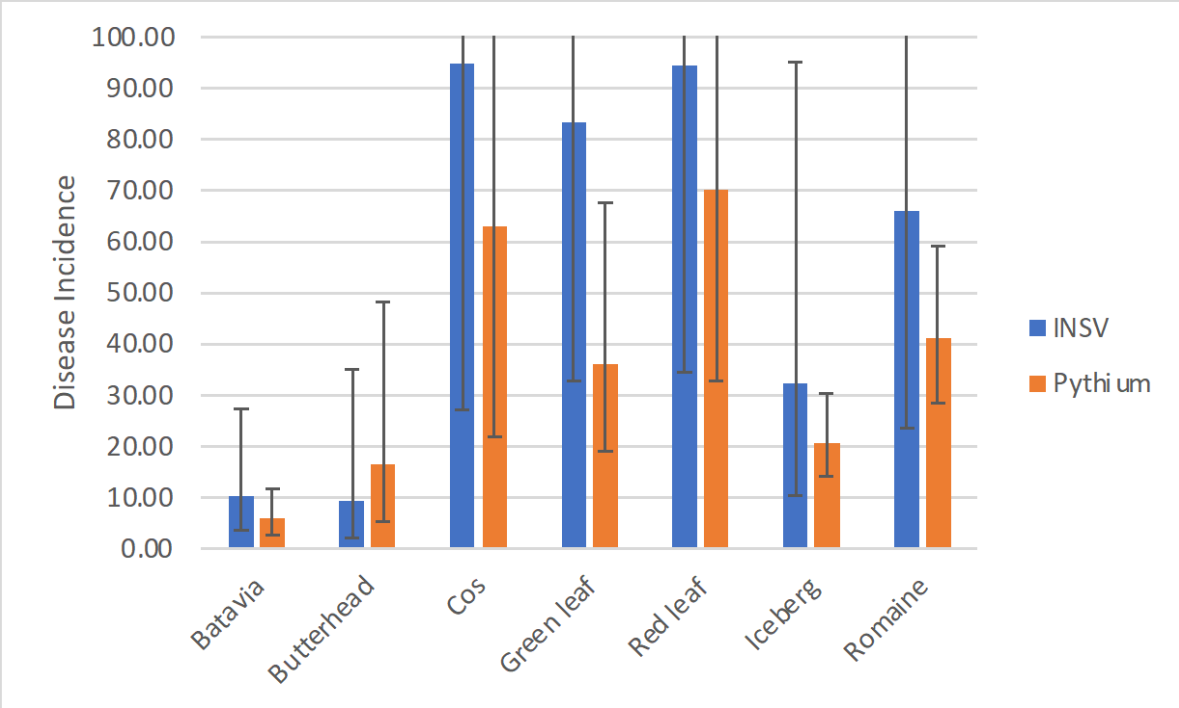
- Pair field data with genetic linkage map (840 SNPs)
- Highly significant QTL on linkage group 2
- Confirmed QTL in greenhouse experiments
- June 2023 field- not enough disease, August 2023 field- enough disease?
- Additional sampling in August 2023 planting
- Developing MAS assay





What about solutions today?

- **Breeding takes time!**
- **Evaluate popular commercial varieties available NOW**
- **2022 and 2023 Pythium/INSV variety trials**
- **Results direct breeding efforts**
- **INSV and Pythium incidence (% symptomatic plants)**



Romaine varieties under Pythium and INSV

- **Most romaine varieties were highly susceptible**
- **If resistant to INSV, was resistant to Pythium**

Romaine Type	Sept 14 INSV	Sept 13 Pythium
Patton ★	11.63 (22%)	10.01
Copious	18.52 (50%)	7.53
1024	22.21	5.61
SR2-21-33B	35.40	21.60
Momentous	44.15	20.24
7346	93.22	68.73
22PT/04	94.92	89.21
Teton	96.55	42.70
201	96.55	65.55

Romaine Type	Sept 14 INSV	Sept 13 Pythium
203	96.55	75.08
Adicamp	96.64	53.97
Estiada	96.64	67.90
Nun 06299	98.31	30.47
22PT/03	98.31	67.04
ROM 1184	98.31	82.85
SR2-21-16B	98.31	89.28
22PT/02 ★	100.00	79.50
22PT/01	100.00	82.62

- **Patton (low incidence) and 22PT/02 (high incidence) used for Pythium greenhouse assays**

Crisphead varieties under Pythium and INSV

- **More incidence variation in crisphead varieties**
- **More varieties with differential INSV/Pythium reaction**

Iceberg Type	Sept 14 INSV	Sept 13 Pythium
Paraiso	4.71 (83%)	5.00
22PT/07	5.95 (50%)	4.00
Telluride	6.92 (50%)	3.39
102	11.25	10.61
Molera	11.63	10.96
Lockwood	13.61	11.93
101	23.15	22.01
22PT/08	25.31	9.94
Primo	30.16	28.92
103	36.35	19.69
Regency	36.76	20.49
SVS 107	37.74	19.34
3427	38.37	17.92

Iceberg Type	Sept 14 INSV	Sept 13 Pythium
San Miguel	38.67	30.02
San Andreas	41.79	8.14
Meridian	42.56	40.40
Armstrong	58.96	41.86
Nun 00300	59.30	31.12
22PT/06	61.61	32.12
3262	63.90	29.61
SVLC 4050	69.66	38.74
104	71.84	48.48
Powerball	78.32	54.76
105	81.04	59.40
Nun 00276	98.31	79.93

Co-infection with INSV

- **Is there a connection between INSV and soilborne pathogens?**
- **Increase in many soilborne diseases**

USDA INSV breeding goals

1. Identify new sources of resistance
2. Pyramid sources of resistance
3. Introgress resistance into desirable market types
4. Develop mapping populations to identify linked markers
5. Test against multiple diseases

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