Application of High Throughput Phenotyping Tools for Germplasm Screening in Potato

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Overview

- Tri-State Potato Breeding and Variety Development
- Screening Germplasm for Resistance to Verticillium Wilt
- Aerial Imaging Applications for Disease Tolerance Screening
- Volatile Organic Compounds Profiling as a tool for Germplasm Screening

Tri-State History

- Started in 1985
- USDA/ARS breeding programs develop germplasm needs for the industry and will be evaluated by state land grant universities of ID, OR and WA
- Original intent of the stake holders:
  - Create a collaborative variety development program that would allow ARS scientists to concentrate on basic genetics and germplasm development, while instituting an applied research effort for smooth delivery of new varieties to the PNW potato industry

30 years of strong and successful collaboration

Tri-State Approach

USDA-ARS / OSU
Research Geneticists, Breeders

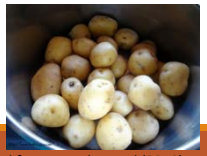
Land Grant State Universities
Breeders, Agronomists, physiologists pathologists, entomologists, extension specialists

USDA-ARS

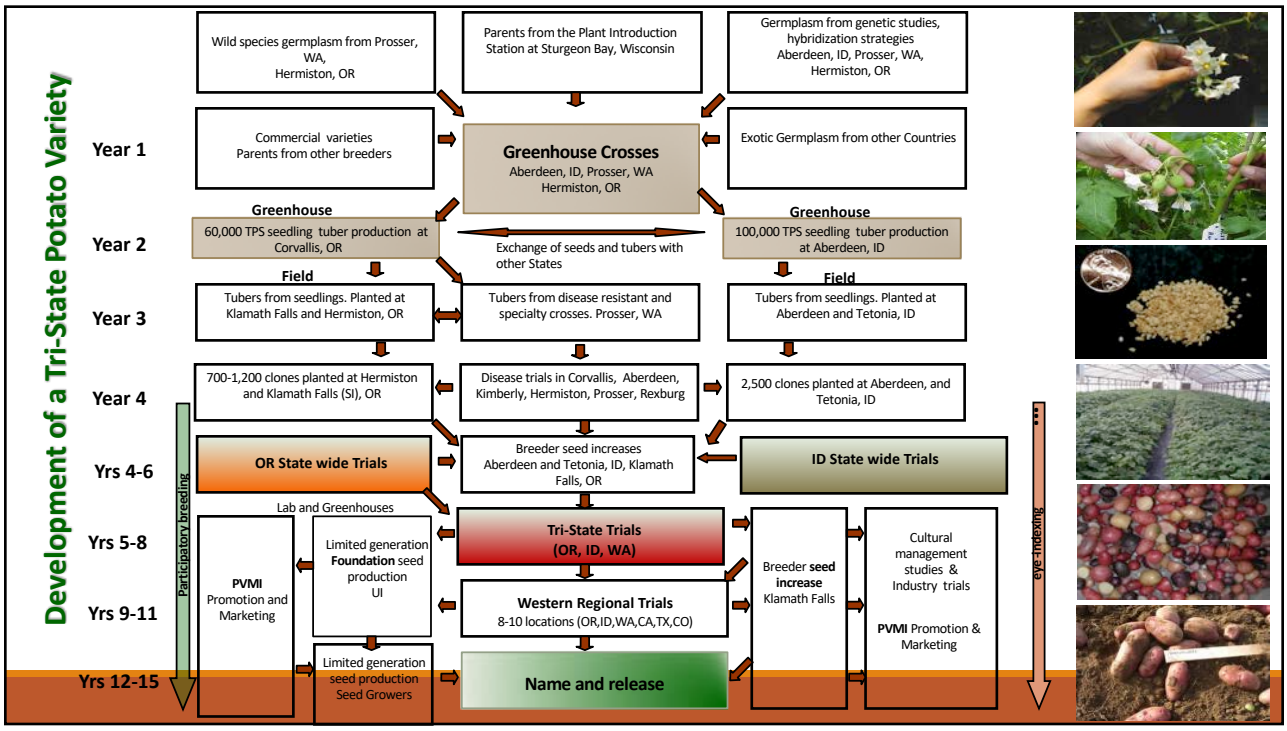
Industry – growers, processors, packers

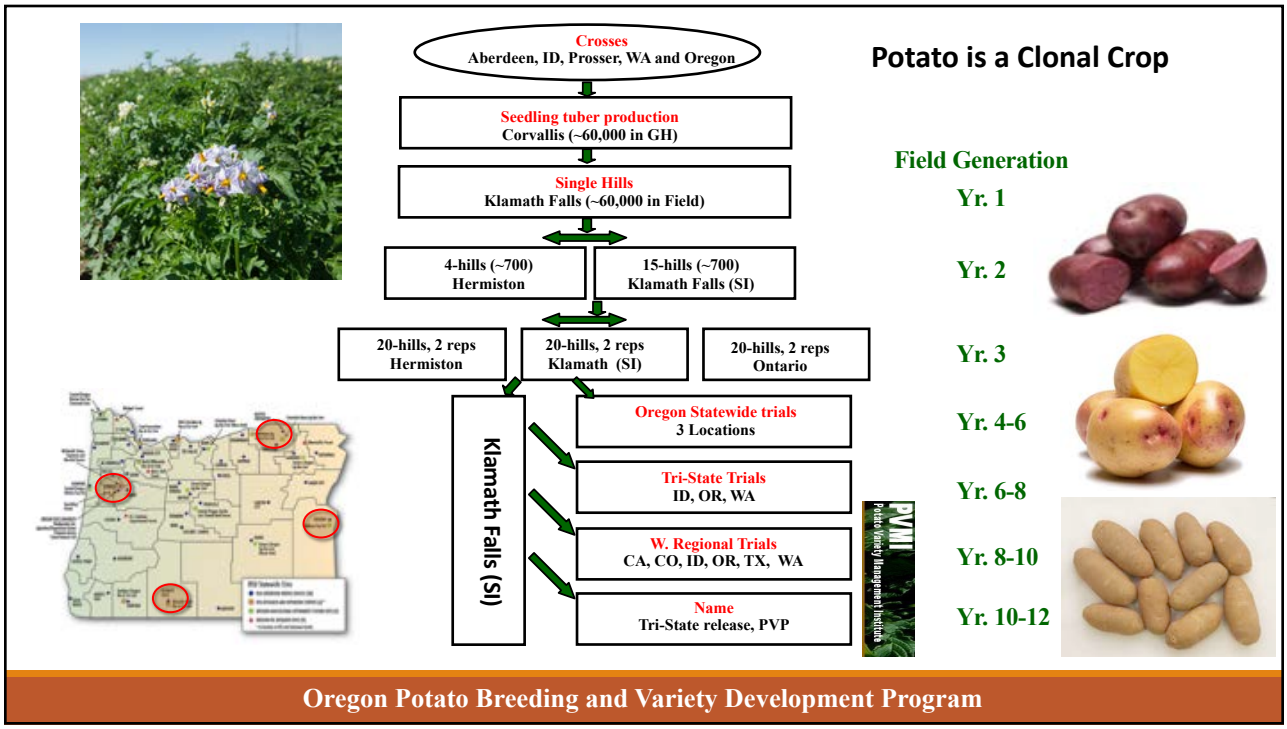
Potato Commissions – ID, OR, WA

Potato Variety Management Institute (PVMI)



Slide adapted from Knowles et al (2010)


Development of a Tri-State Potato Variety
Year 1
Year 2
Year 3
Year 4
Yrs 4-6
Yrs 5-8
Yrs 9-11
Yrs 12-15
Participatory breeding
Wild species germplasm from Prosser, WA, Hermiston, OR
Parents from the Plant Introduction Station at Sturgeon Bay, Wisconsin
Germplasm from genetic studies, hybridization strategies Aberdeen, ID, Prosser, WA, Hermiston, OR
Commercial varieties Parents from other breeders
Greenhouse Crosses
Aberdeen, ID, Prosser, WA Hermiston, OR
Exotic Germplasm from other Countries
Greenhouse
60,000 TPS seedling tuber production at Corvallis, OR
Exchange of seeds and tubers with other States
Greenhouse
100,000 TPS seedling tuber production at Aberdeen, ID
Field
Tubers from seedlings. Planted at Klamath Falls and Hermiston, OR
Tubers from disease resistant and specialty crosses. Prosser, WA
Field
Tubers from seedlings. Planted at Aberdeen and Tetonia, ID
700-1,200 clones planted at Hermiston and Klamath Falls (SI), OR
Disease trials in Corvallis, Aberdeen, Kimberly, Hermiston, Prosser, Rexburg
2,500 clones planted at Aberdeen, and Tetonia, ID
OR State wide Trials
Breeder seed increases Aberdeen and Tetonia, ID, Klamath Falls, OR
ID State wide Trials
Lab and Greenhouses
Tri-State Trials (OR, ID, WA)
PVMI Promotion and Marketing
Limited generation Foundation seed production UI
Breeder seed increase Klamath Falls
Cultural management studies & Industry trials
PVMI Promotion & Marketing
Western Regional Trials
8-10 locations (OR,ID,WA,CA,TX,CO)
Limited generation seed production Seed Growers
Name and release
eye-indexing


Crosses
Aberdeen, ID, Prosser, WA and Oregon
Seedling tuber production
Corvallis (~60,000 in GH)
Single Hills
Klamath Falls (~60,000 in Field)
4-hills (~700)
Hermiston
15-hills (~700)
Klamath Falls (SI)
20-hills, 2 reps
Hermiston
20-hills, 2 reps
Klamath (SI)
20-hills, 2 reps
Ontario
Klamath Falls (SI)
Oregon Statewide trials
3 Locations
Tri-State Trials
ID, OR, WA
W. Regional Trials
CA, CO, ID, OR, TX, WA
Name
Tri-State release, PVP
PVMI
Potato Variety Management Institute
Potato is a Clonal Crop
Field Generation
Yr. 1
Yr. 2
Yr. 3
Yr. 4-6
Yr. 6-8
Yr. 8-10
Yr. 10-12
Oregon Potato Breeding and Variety Development Program

Breeding Objectives

- Develop new russet potatoes
  - Dual purpose russet varieties (ID)
  - Individual market oriented russet varieties (OR)
- Breeding for resistance to major pests and diseases
  - PVY, Verticillium wilt, Zebra Chip, TRV, PMTV, **CRKN**, Scab etc.
- Breeding of specialty potatoes
  - Reds/yellows/purples
  - High anthocyanins, minerals, carotenoids, Nutrients, Flavor
- Breeding for cold sweetening resistance and high nutrient efficiency
  - Low acrylamide, low N input

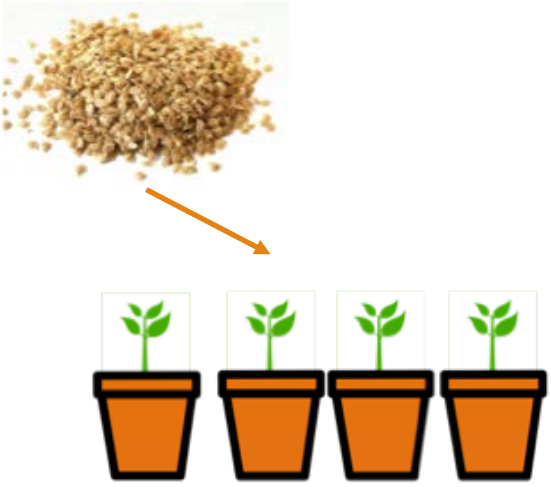
Payette Russet

Overall Goal
Release & commercialize new potato varieties that will directly benefit all segments of the PNW potato industry

Verticillium Wilt (*Verticillium* species)

Image Sources:
PNW Handbook
University of Minnesota Extension

Verticillium dahliae Resistance Screening



1 to 4 seedlings per Plant Introduction

Accession	Species	Ploidy	# Clones
PI 498148	S. andreanum	2x	4
PI473361	S. boliviense	2x	1
PI265861	S. boliviense	2x	4
PI545912	S. brevicaule	2x	4
PI243508	S. bulbocastanum	2x	4
PI243512	S. bulbocastanum	2x	4
PI275187	S. bulbocastanum	2x	4
PI498011	S. bulbocastanum	2x	4
PI652828	S. guerreroense	6x	4
PI239423	S. hougasii	6x	4
PI283107	S. hougasii	6x	4
PI275182	S. iopetalum	6x	4
PI597682	S. iopetalum	6x	3
PI498249	S. iopetalum	6x	1
PI275181	S. iopetalum	6x	4
PI498022	S. iopetalum	6x	4
PI498024	S. iopetalum	6x	3
PI275183	S. iopetalum	6x	4
PI320265	S. stenophyllidium	2x	4
PI545815	S. stenophyllidium	2x	4
PI643997	S. stoloniferum	4x	4
PI632334	S. stoloniferum	4x	4
Russet Burbank	S. tuberosum	4x	8

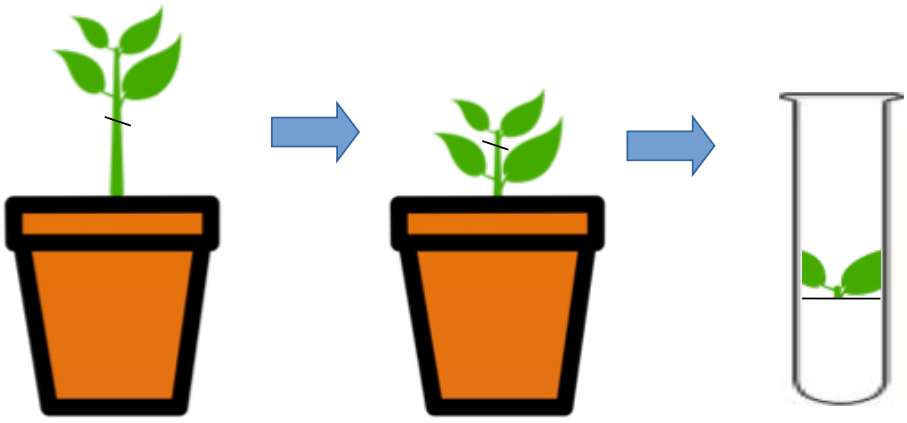
Verticillium dahliae Resistance Screening

- 30,000,000 Conidia VCG4A
- Most aggressive isolate in the Columbia basin of OR-WA

Verticillium dahliae Resistance Screening

- Inoculated plants evaluated for their survival up to 12 weeks

Verticillium dahliae Resistance Screening



Screening for New Sources of Resistance to VW

Initial Screening Results

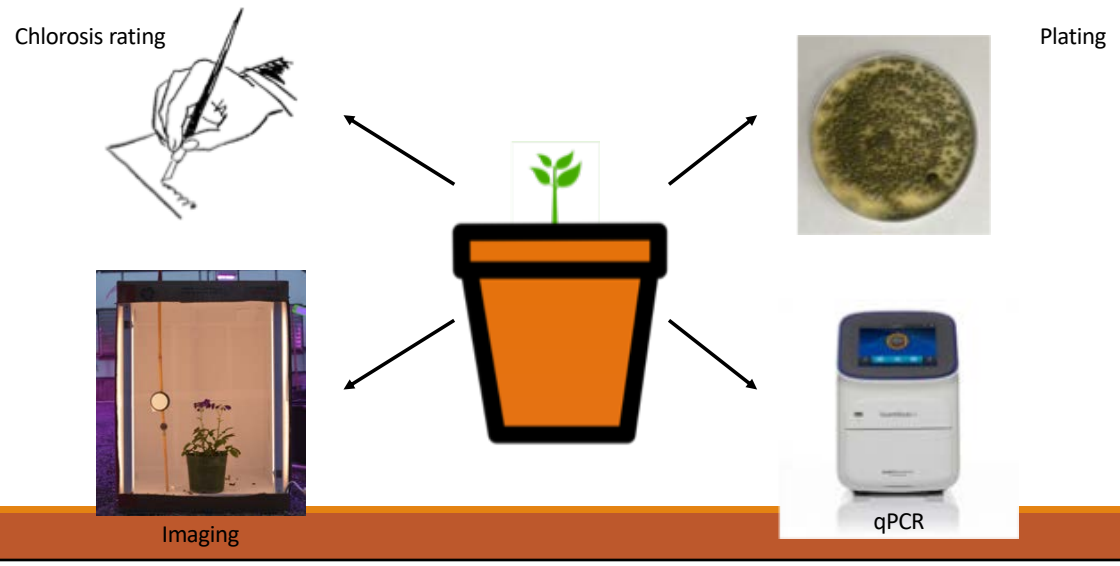
Accession	Species	Ploidy	# Clones	# Clones Alive	# Clones Retained
PI 498148	S. andreanum	2x	4	2	2
PI473361	S. boliviense	2x	1	0	0
PI265861	S. boliviense	2x	4	0	0
PI545912	S. brevicaule	2x	4	0	0
PI243508	S. bulbocastanum	2x	4	0	0
PI243512	S. bulbocastanum	2x	4	2	0
PI275187	S. bulbocastanum	2x	4	0	0
PI498011	S. bulbocastanum	2x	4	2	1
PI652828	S. guerreroense	6x	4	0	0
PI239423	S. hougasii	6x	4	2	1
PI283107	S. hougasii	6x	4	2	1
PI275182	S. iopetalum	6x	4	3	2
PI597682	S. iopetalum	6x	3	1	0
PI498249	S. iopetalum	6x	1	0	0
PI275181	S. iopetalum	6x	4	4	1
PI498022	S. iopetalum	6x	4	0	0
PI498024	S. iopetalum	6x	3	0	0
PI275183	S. iopetalum	6x	4	1	0
PI320265	S. stenophyllidium	2x	4	0	0
PI545815	S. stenophyllidium	2x	4	0	0
PI643997	S. stoloniferum	4x	4	0	0
PI632334	S. stoloniferum	4x	4	0	0
Russet Burbank	S. tuberosum	4x	8	3	-

- 80 seedlings from 22 wild potato accessions
- 8 seedlings survived initial screening

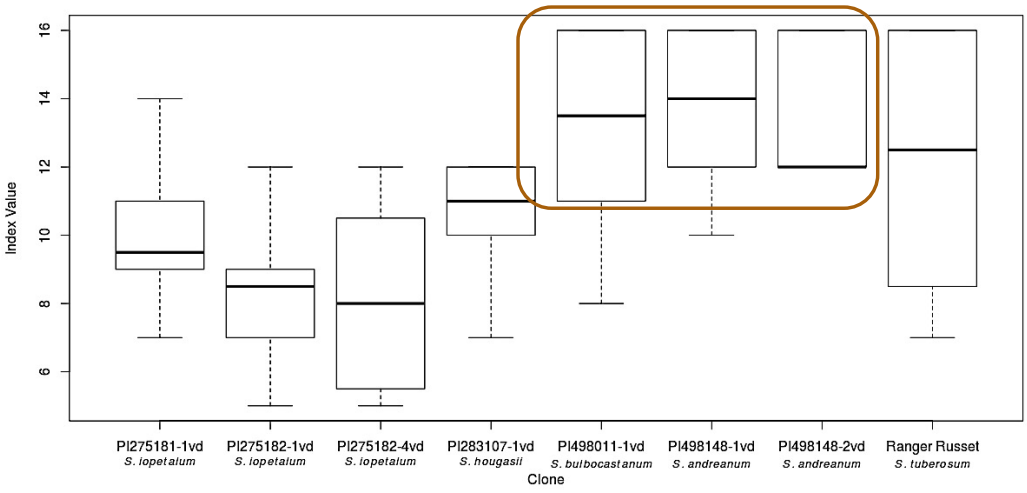
VW Initial Screening Results

Species	PI	# Clones Survived
S. andreanum	498148	2
S. bulbocastanum	498011	1
S. hougasii	239423	1
S. hougasii	283107	1
S. iopetalum	275181	1
S. iopetalum	275182	2

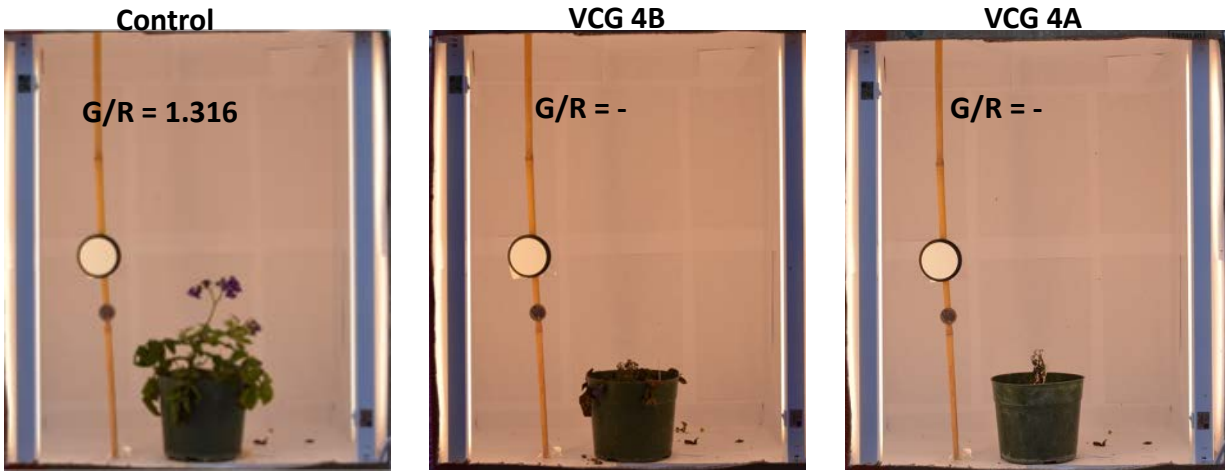
Replicated Screening for Verticillium Resistance



Replicated Screening for Verticillium Resistance

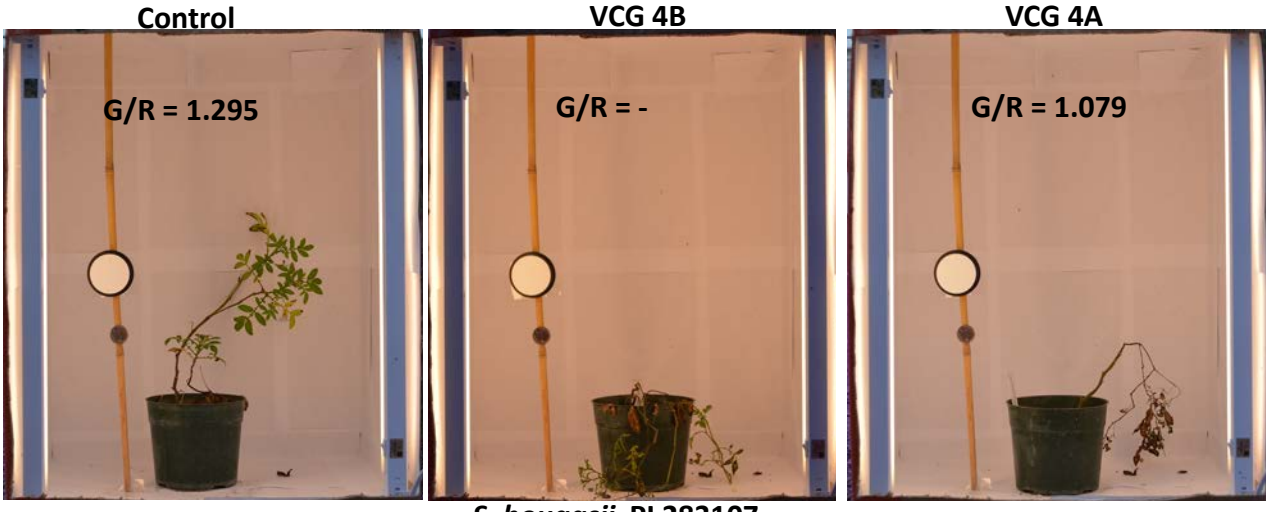


Replicated Screening for Verticillium Resistance



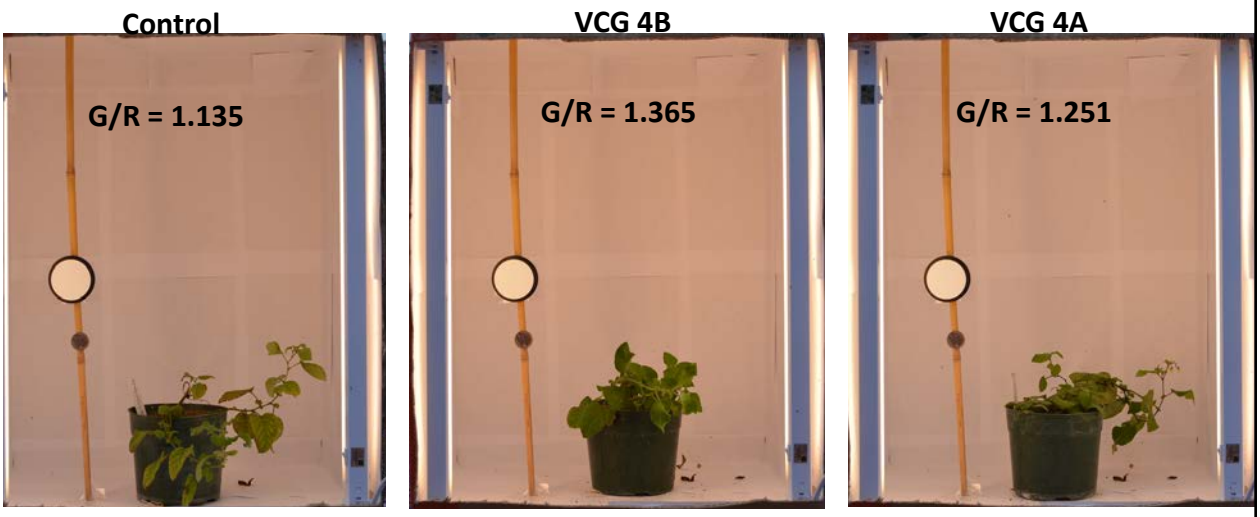
S. iopetalum **PI 275182**

Replicated Screening for Verticillium Resistance



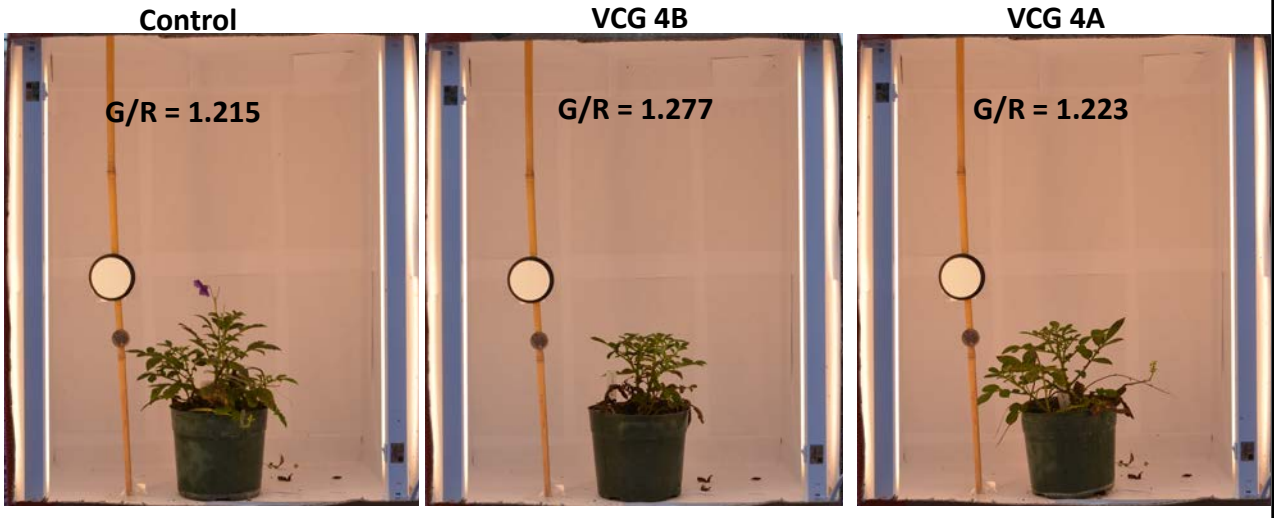
S. hougasii **PI 283107**

Replicated Screening for Verticillium Resistance



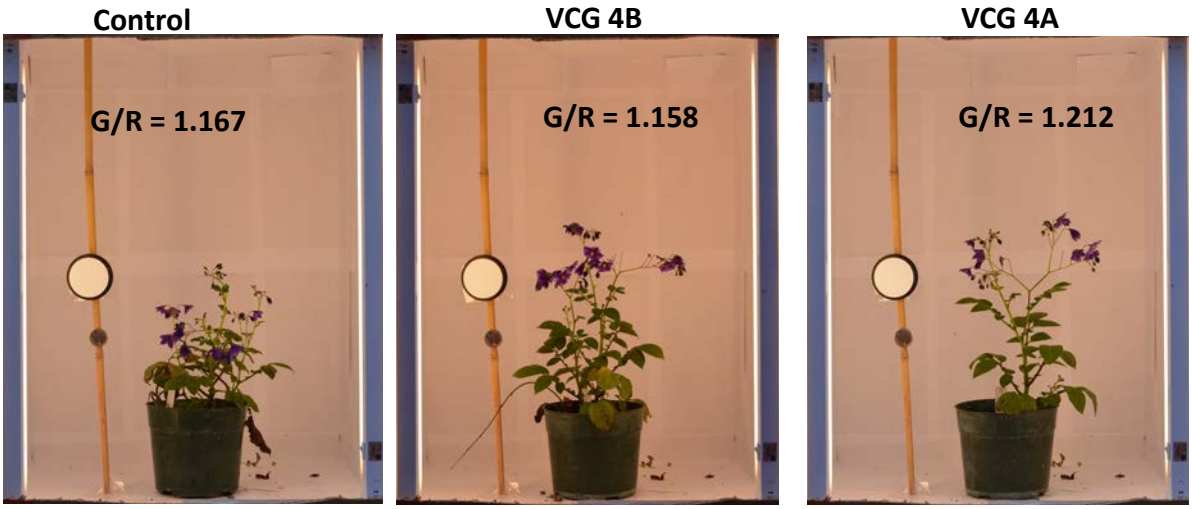
S. bulbocastanum PI 498011

Replicated Screening for Verticillium Resistance



S. andreanum PI 498148-1

Replicated Screening for Verticillium Resistance



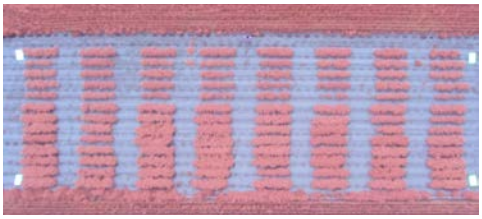
S. andreanum **PI 498148-2**

Replicated Screening for Verticillium Resistance

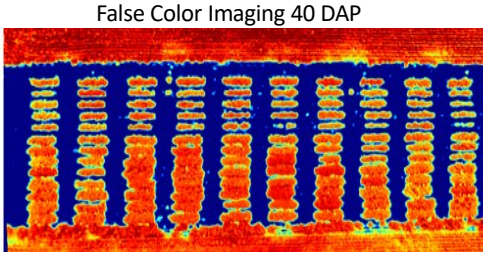
Species	PI	# Clones Survived
S. andreanum	498148	2
S. bulbocastanum	498011	1
~~*S. hougasii*~~	~~239423~~	~~1~~
~~*S. hougasii*~~	~~283107~~	~~1~~
~~*S. iopetalum*~~	~~275181~~	~~1~~
~~*S. iopetalum*~~	~~275182~~	~~2~~

Aerial Imaging applications in Potato Breeding: Biotic Stress Screening

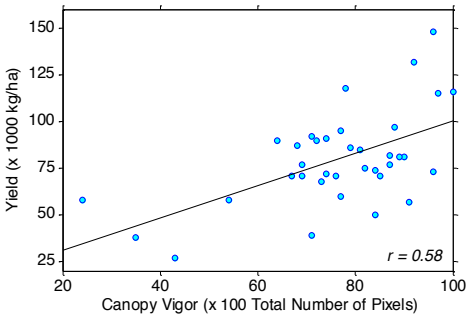
Early Die field screening



False Color Imaging 40 DAP

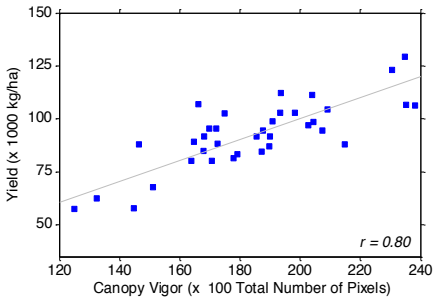


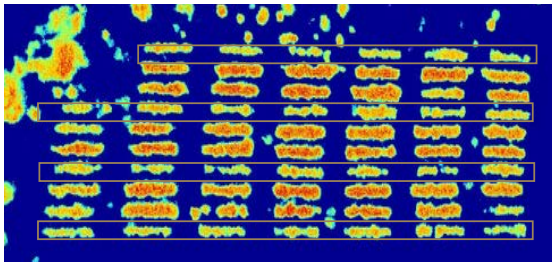
NDVI Imaging 40 DAP



Aerial Imaging applications in Potato Breeding: Biotic Stress Screening

Potato virus Y field screening



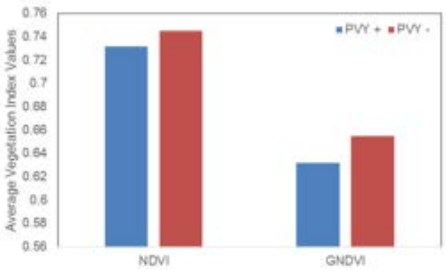


NDVI Imaging – 40 DAP

Aerial Imaging applications in Potato Breeding: Biotic Stress Screening

Potato virus Y field screening

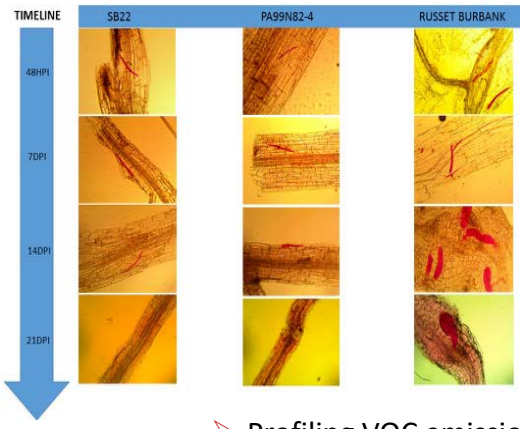
Psuedocolor Imaging

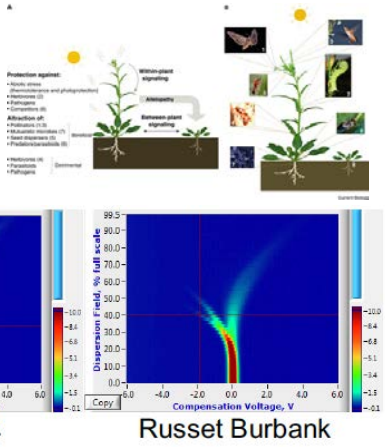


NDVI and GNDVI values of potato plants grown from PVY infected and PVY free seed pieces

Profiling Volatile Organic Compounds

Columbia Root Knot Nematode Screening





PA99N824 Russet Burbank

FAIMS Spectra (positive ions) at 21 days post inoculation

- Profiling VOC emissions has potential in germplasm screening

Conclusion

- High Throughput Phenotyping has potential in Germplasm Screening
- Once validated – remote sensing tools can add value in potato breeding
  - Field screening for pest/disease
  - Nitrogen and water use efficiency
  - Quality
- Aerial imaging has potential applications in Potato Seed Industry
  - PVY rouging
- VOCs have potential use in screening for soil borne pathogens like Nematodes
  - Can it replace tedious nematode screening..

Funding Sources

- Potato Commissions of OR, WA, ID
- USDA-NIFA Special Grant
- Cooperative Research Agreements USDA/ARS

Thank You