Grape breeding at UC Davis

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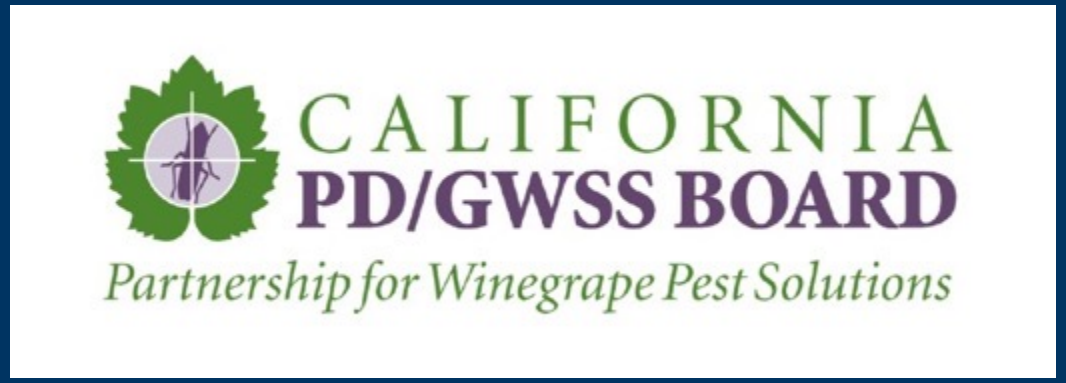
Funding


CALIFORNIA
GRAPE ROOTSTOCK
COMMISSION


CALIFORNIA
PD/GWSS BOARD
Partnership for Winegrape Pest Solutions

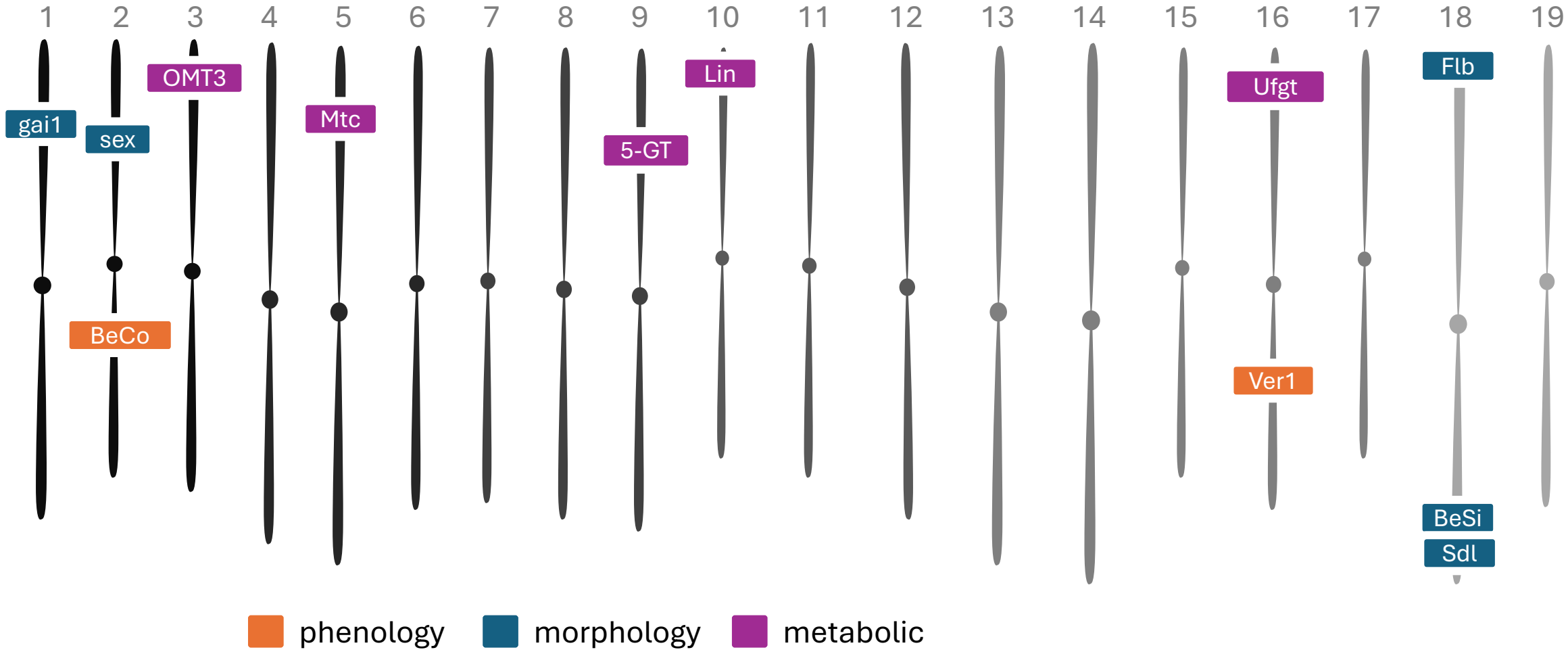

AMERICAN VINEYARD
FOUNDATION


USDA
NIFA

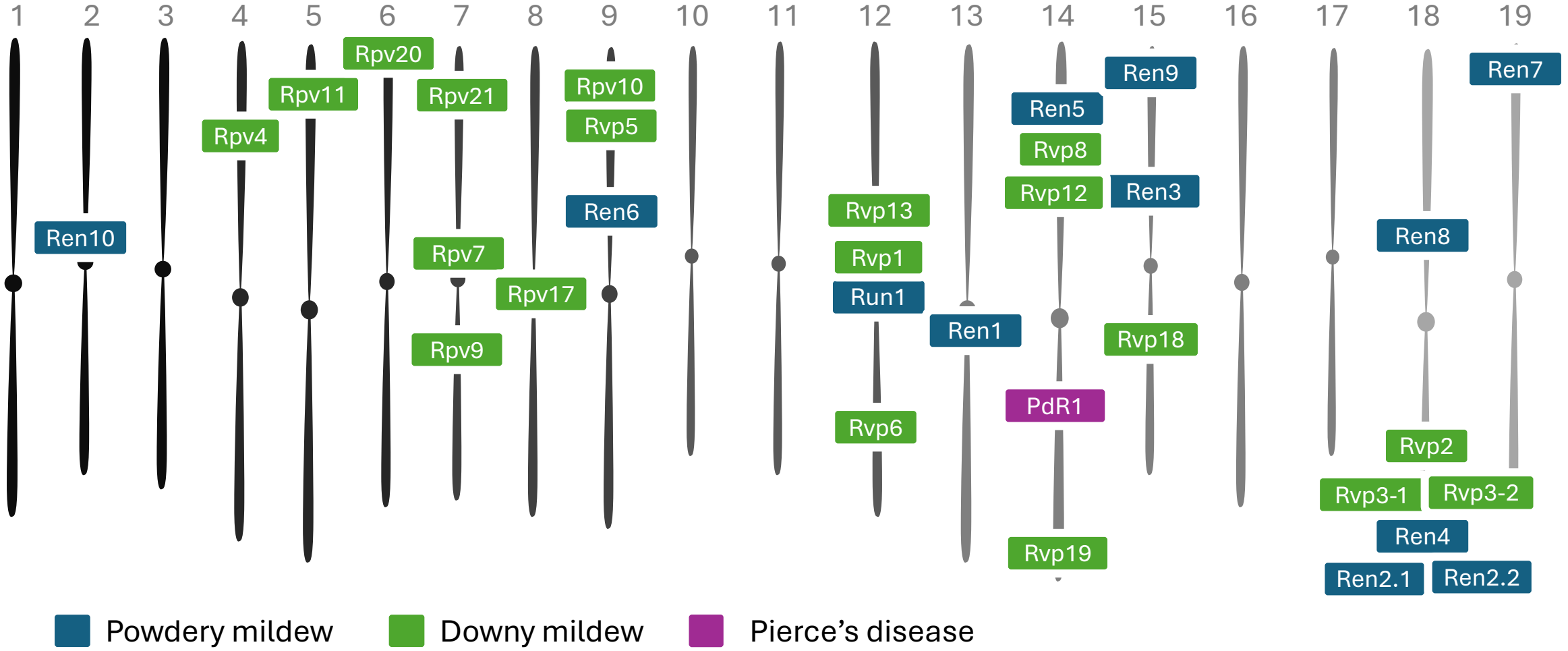

VitisGenIII


BARD
BARD

Historically, grape breeding has focused on single gene traits



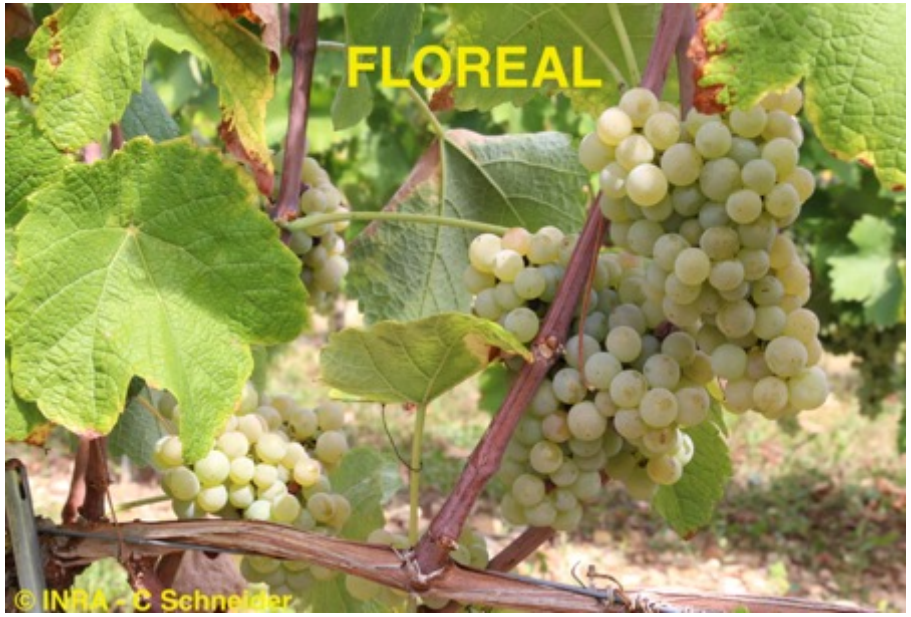
Historically, grape breeding has focused on single gene traits



Development of PM and DM resistant varieties

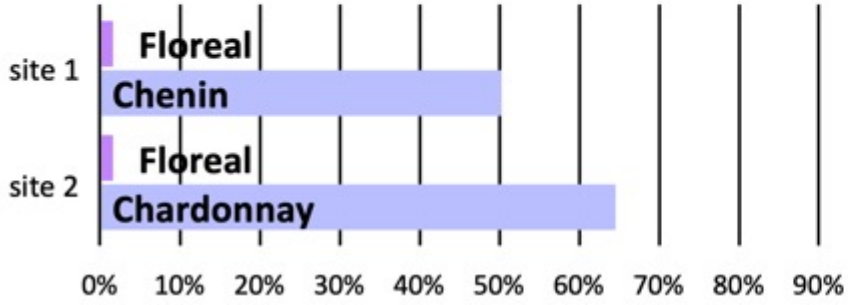
INRA-ResDur1 program, 2018

Floreal
Downy mildew (***Rpv1*** & ***Rpv3***)
Powdery mildew (***Run1*** & ***Ren3***)



Downy mildew (without phytosanitary protection)

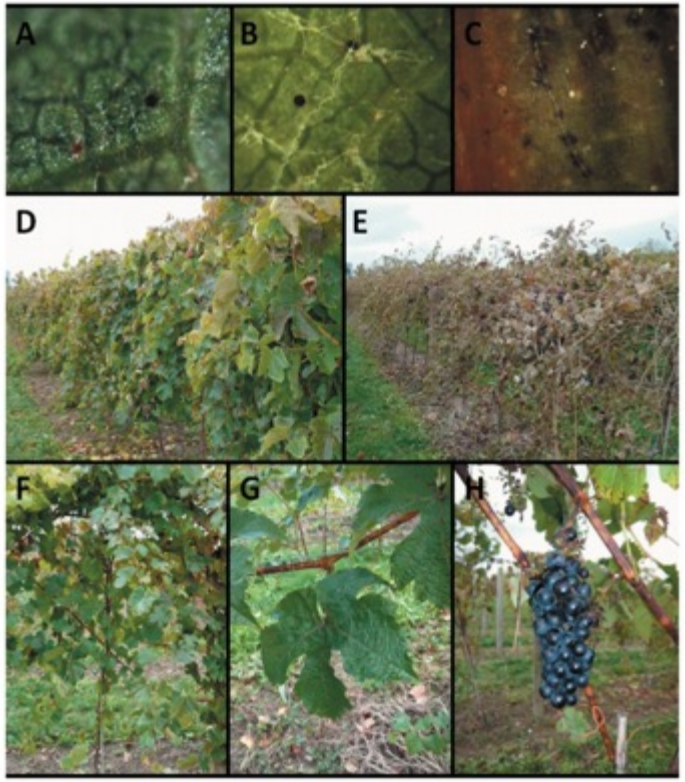
Intensity of damage on **foliage**
(after veraison, case of strong pressure)

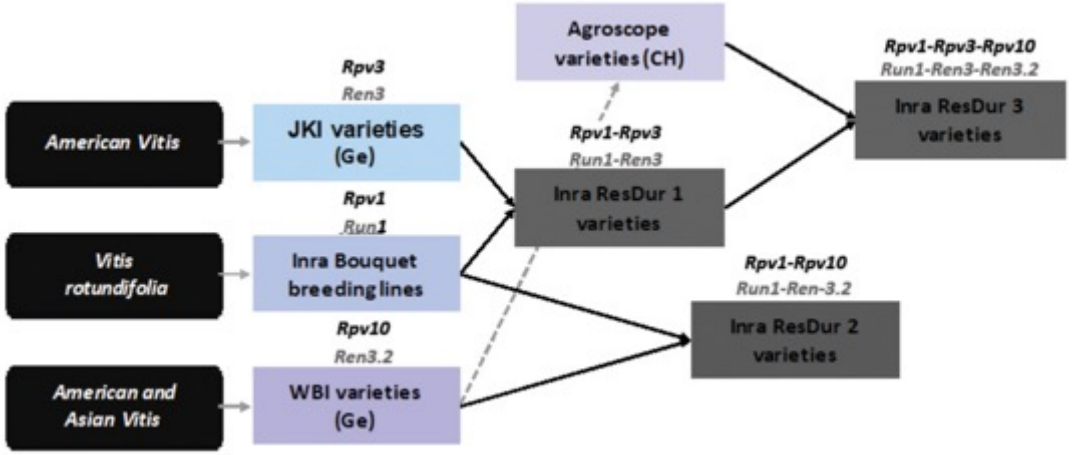


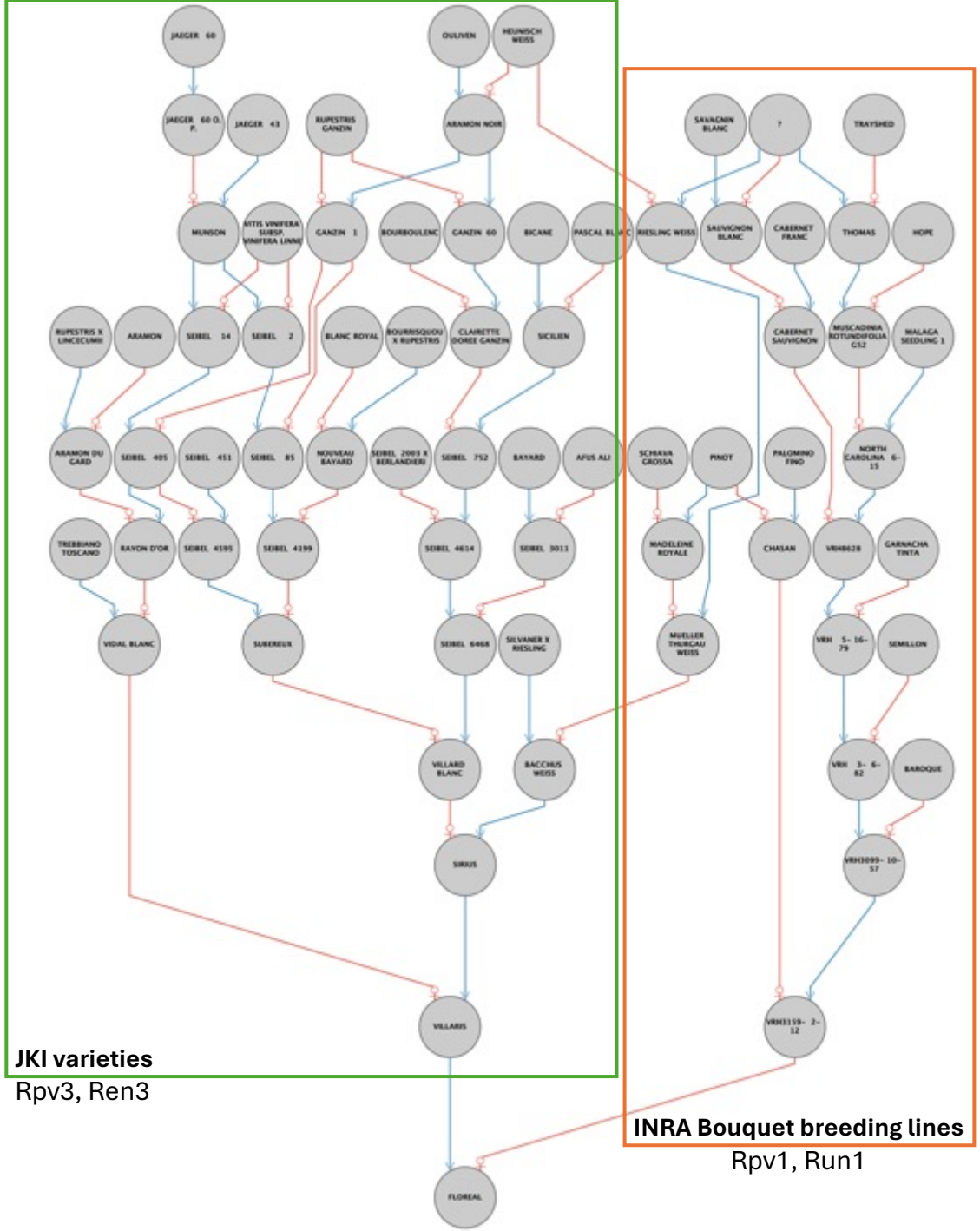
Intensity of damage on **cluster**

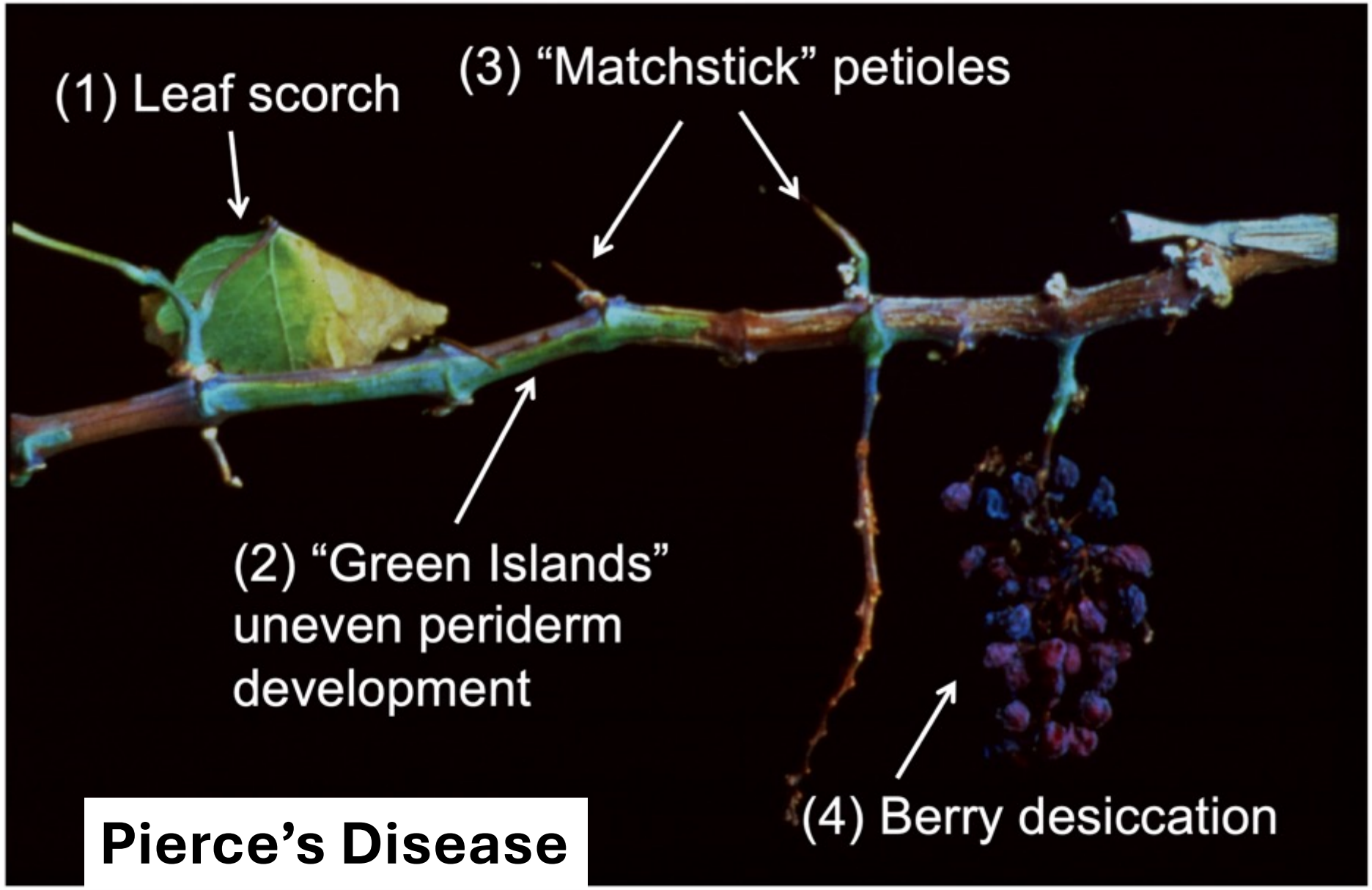
Very rare symptoms on inflorescences or clusters, without impact on the harvest, whereas the control grape varieties are severely impacted.

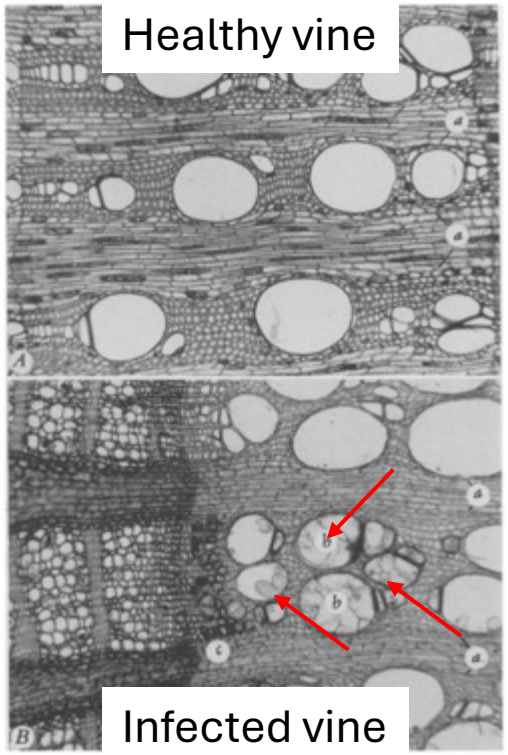
Signs of powdery mildew were observed on 14/113 **Run1-positive** seedlings in October 2010 in Geneva, N.Y











Blockage of vascular tissue caused by *X. fastidiosa*

Development of Pierce's disease resistant varieties

Chr 14

PdR1

V. rupestris × *V. arizonica* b43-17 × *V. vinifera*

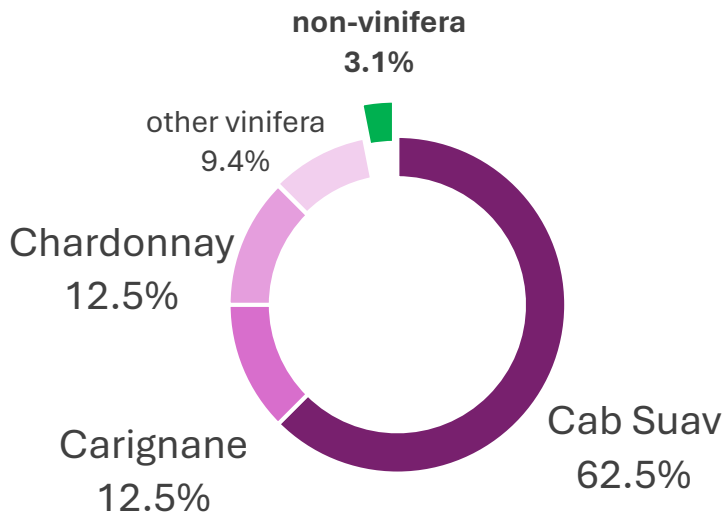
504-20 × B52-89

Cab Sauv × Carignane A81-138 × Chardonnay

F2-35 × U0505-38

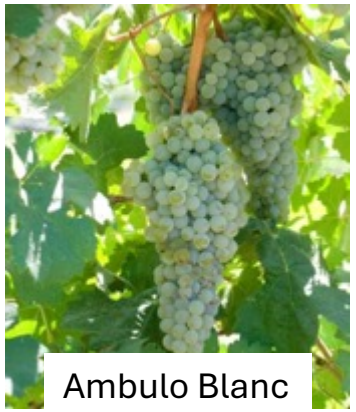
Cab Sauv × 07370-028

Ambulo Blanc



50%

Backcross with vinifera



>95%

Dr. Walker's PD-resistant varieties

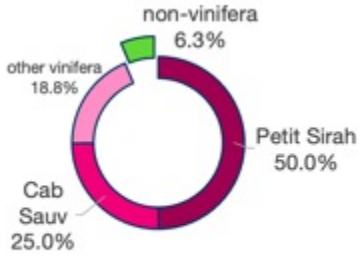
Camminare Noir

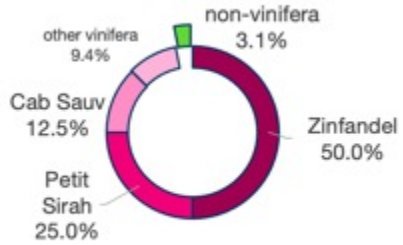
Paseante Noir

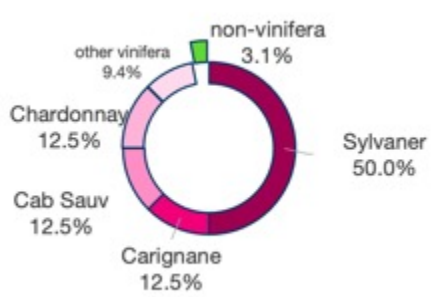
Errante Noir

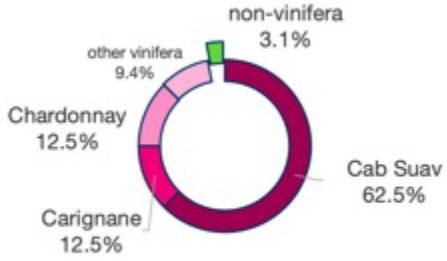
Ambulo Blanc

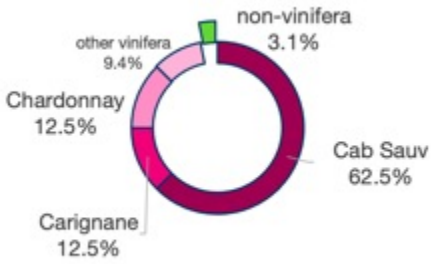
Caminante Blanc







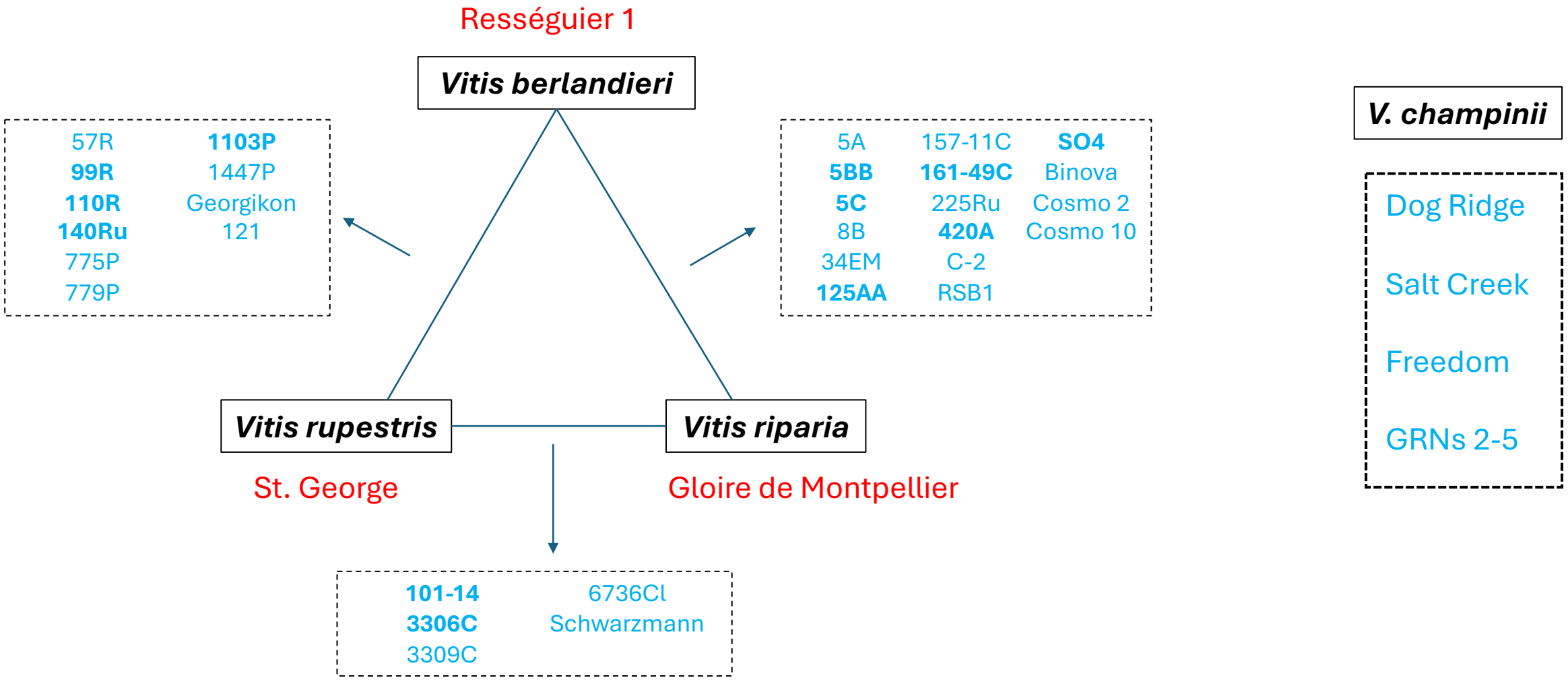




Upcoming new wine grape varieties from UCD

- >95% vinifera
- PdR1 allele, which confers full resistance to Pierce's disease
- Multiple powdery mildew resistance genes for durable protection (e.g., Run1, Ren1, 4, 6, 7)
- For different regions, management, and wine profiles:
    - Early ripening
    - Varietal wines and blends
    - *Teinturiers*
    - Wine profiles influenced by the last vinifera parent

90% of scions are grafted to these three species (as solo or hybrids)



North America is home is >30 *Vitis* species: salt tolerance

- Pest and disease tolerance
- Drought tolerance
- Excellent sources of salinity and boron tolerance

Chloride tolerance (chloride exclusion)

All three vines irrigated with 75 mM NaCl

North America is home is >30 *Vitis* species: boron tolerance

Boron tolerance

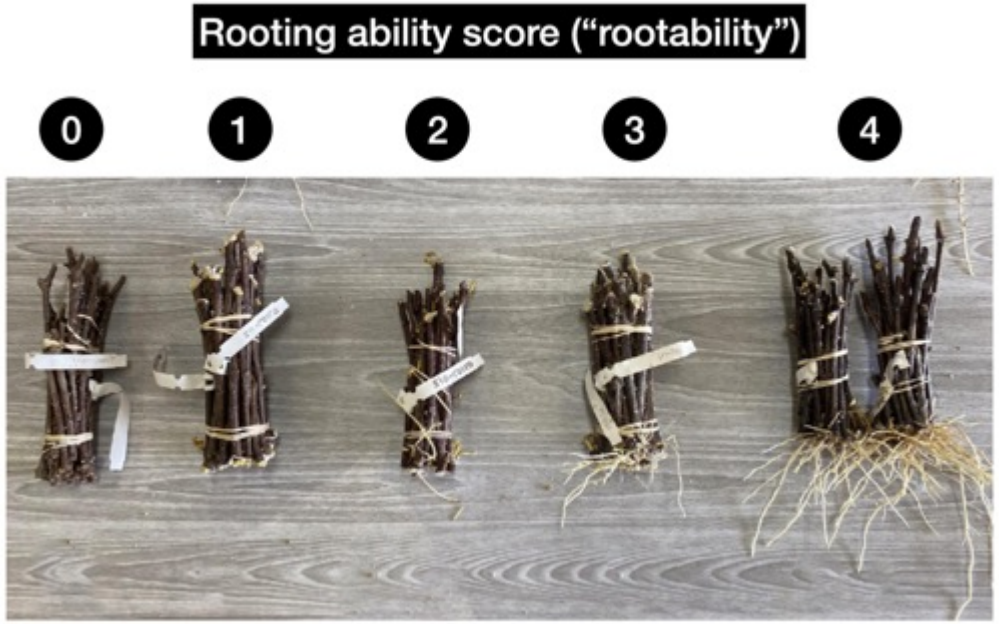
0.5 ppm (control) 8.0 ppm

0.5 ppm 8.0 ppm

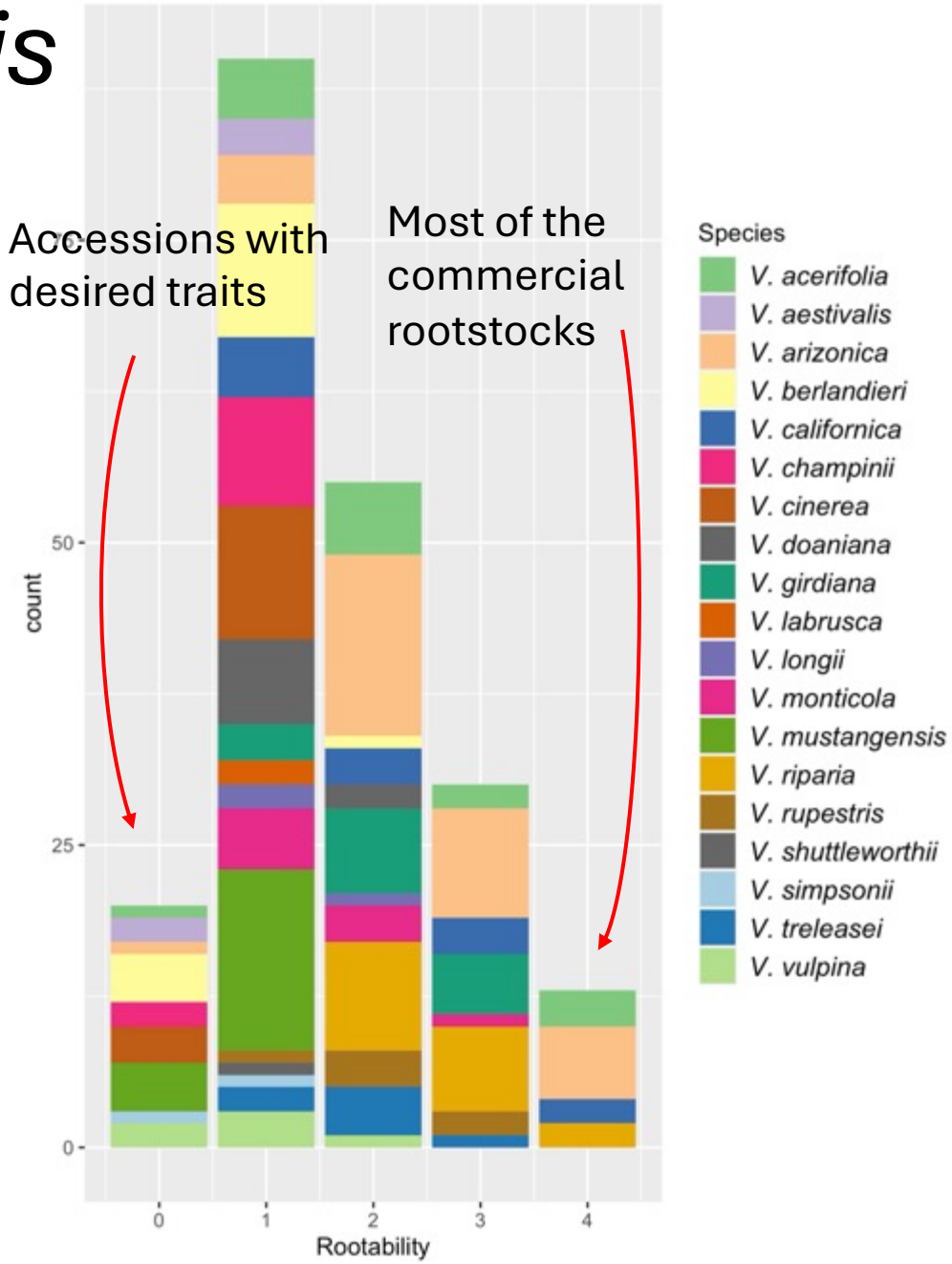
0.5 ppm 8.0 ppm

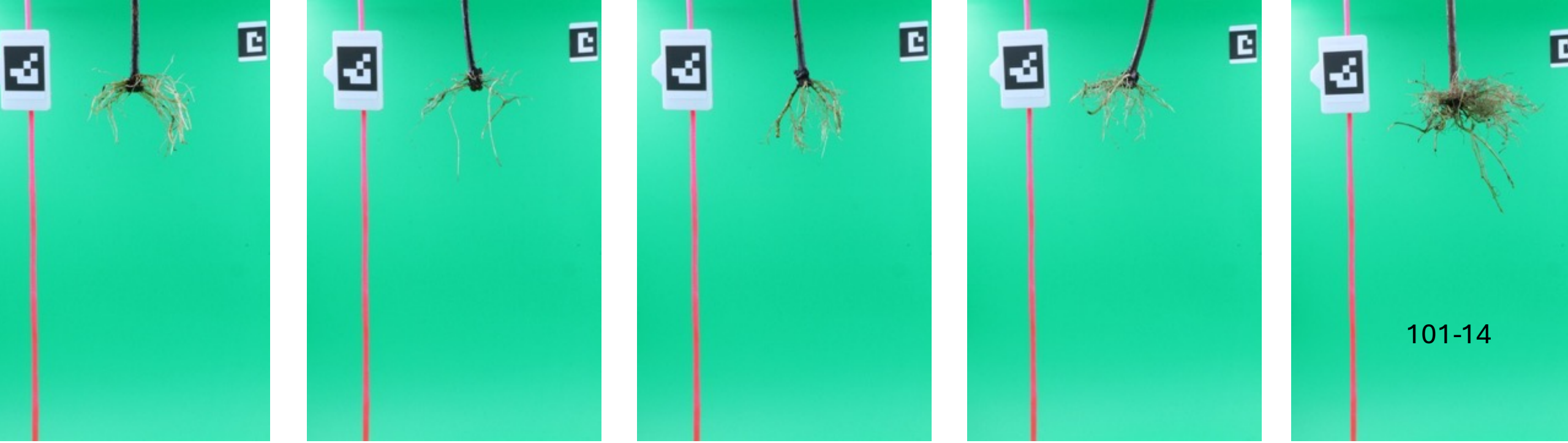
Limitations for using wild *Vitis* germplasm

- Many are difficult to propagate
- **Wood production or characteristics might be limited**
- Reduced vigor



Sadikshya Sharma




101-14

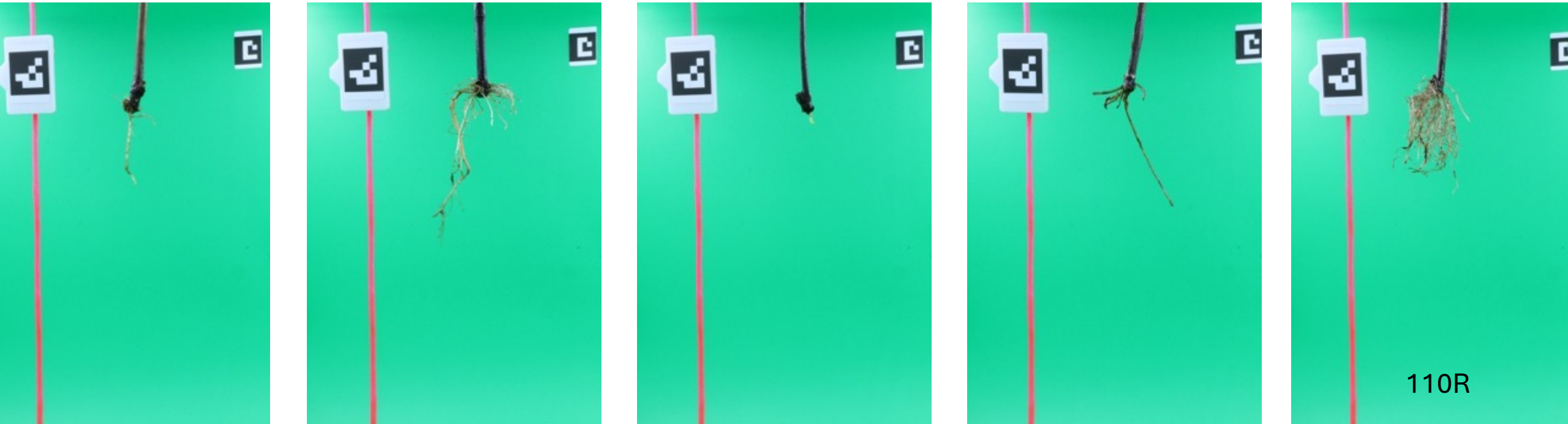
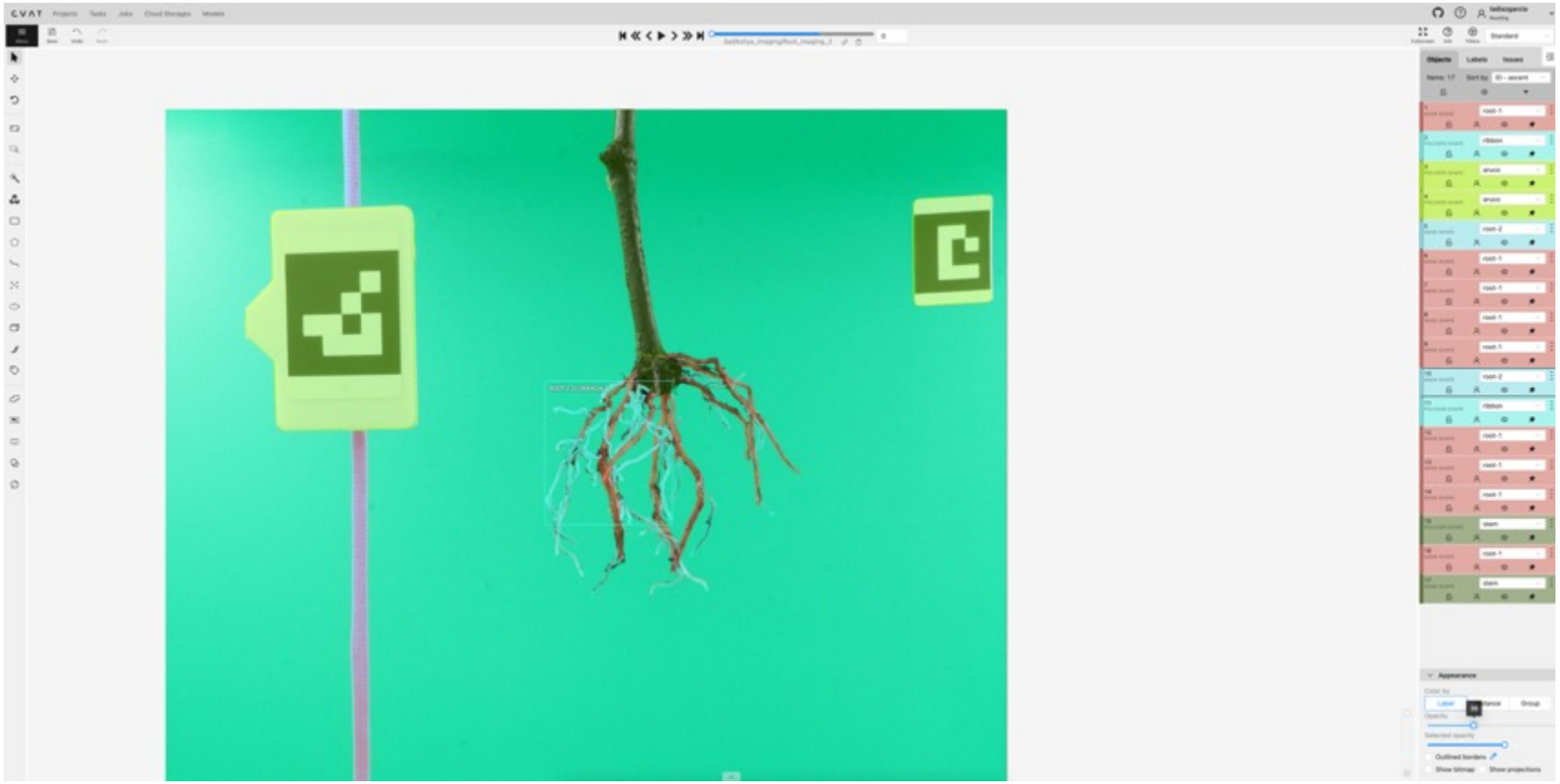

110R

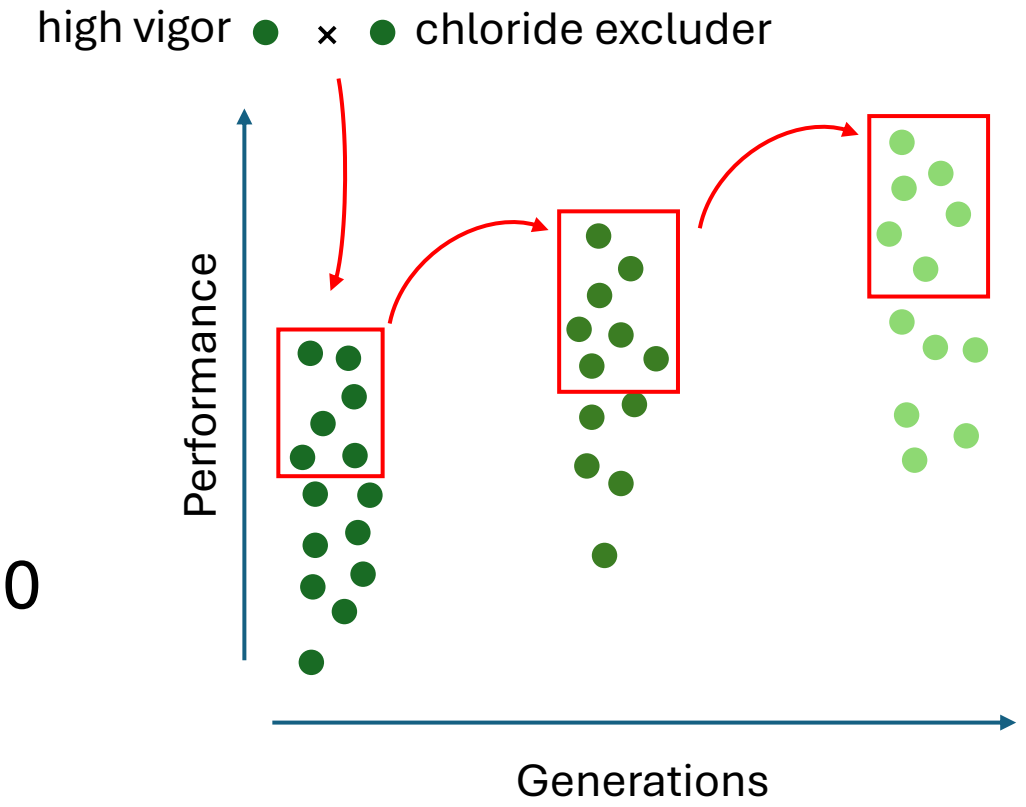
Image annotation for automatic identification of primary and secondary roots



- These accessions have been genotyped
- ~1M high-quality SNP markers/accession
- 400 accessions
- GWAS

The breeding process

- Plant breeding is a process that involves:
  1. parent selection
  2. crossings
  3. progeny evaluation
- Progeny evaluation takes 2 to ~10 years, depending on the trait being targeted



Single-gene vs. polygenic traits

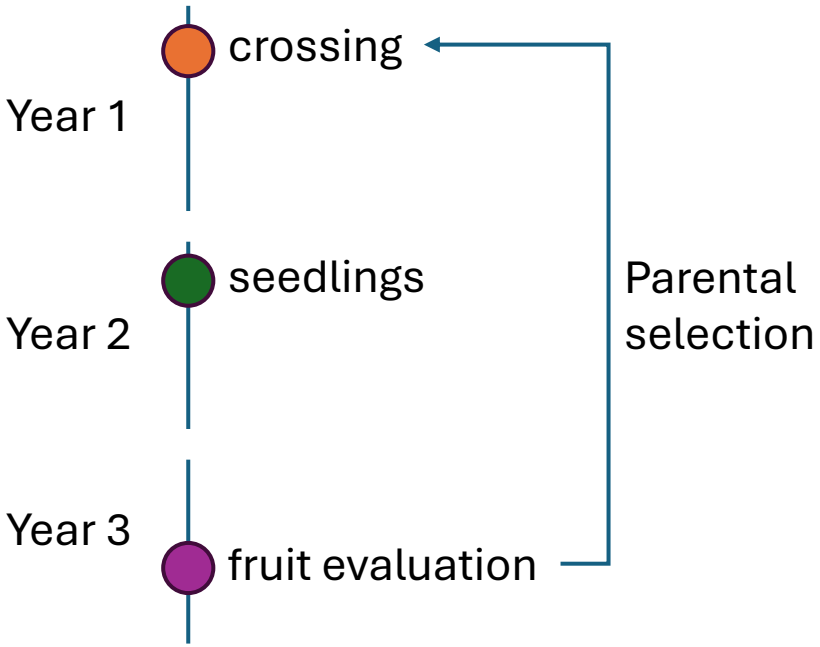
- Single-gene traits can be selected earlier in the breeding pipeline (through phenotypic selection or markers)
  - Controlled by one gene with a very strong effect
  - Phenotypic expression is more consistent year-to-year

- Polygenic traits are complex
  - Controlled by many genes with small effects
  - Larger environmental influence
  - More data (replication) is needed to assess progeny merit and select new parents

Single gene traits

Phenotypic selection

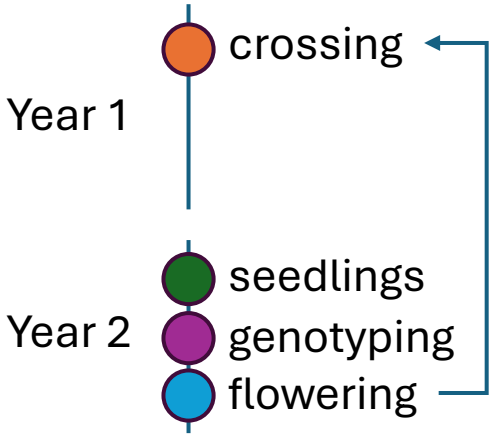
Example: muscat aroma



5 generations = 15 years

Marker-assisted selection

Example: Pierce's disease resistance

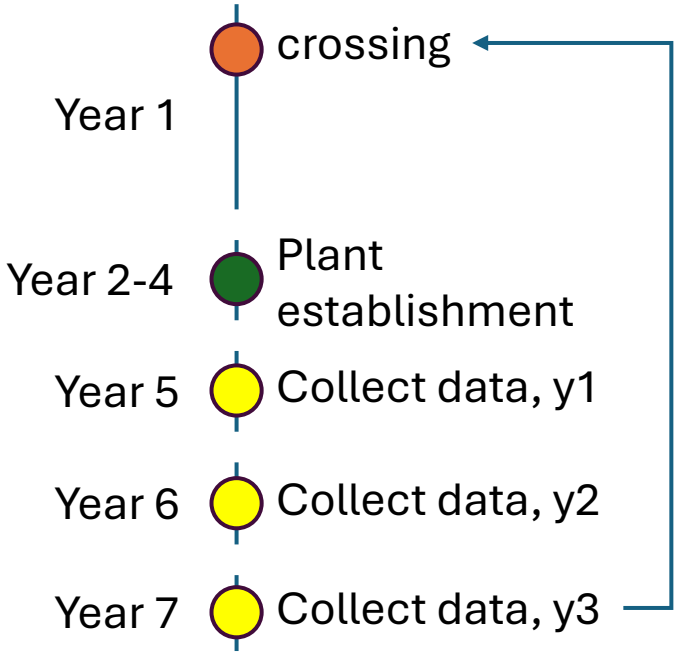


5 generations = 10 years

Polygenic traits

Phenotypic selection

Example: Vigor



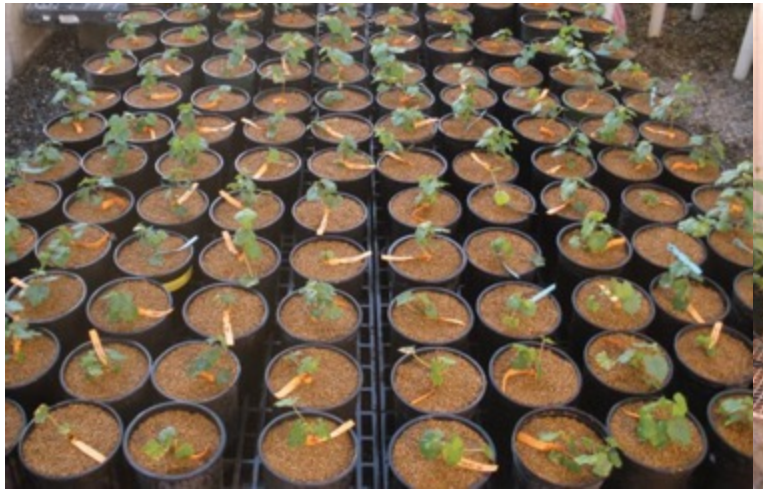
5 generations = 35 years

Approaches to increase rootstock breeding efficiency

- Breeding is a numbers game
- Increasing the size of the breeding populations can increase genetic gain
- Scalable phenotyping techniques are required
- The phenotyping cost per plant is lower at early breeding stages
- Informative traits that can be recorded earlier in the breeding pipeline can enrich the proportion of positive alleles in field trials

Screening for chloride tolerance is time-consuming

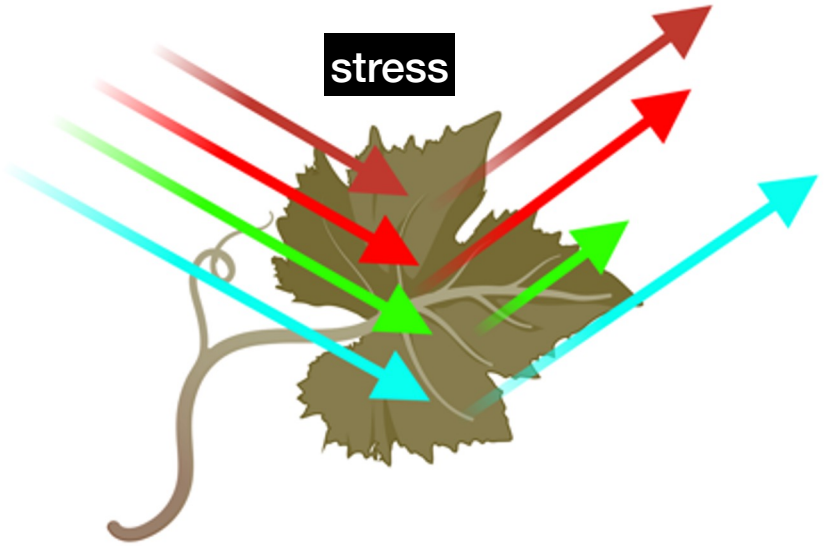
Plant propagation



- Plants grown on fritted clay & treated with salty water (e.g., 50 mM NaCl)
- Leaves are collected, dried, and ground

Chloride concentration is recorded with a chloridometer

Stressed plants produce different spectral profiles



Measure chloride content with the traditional method

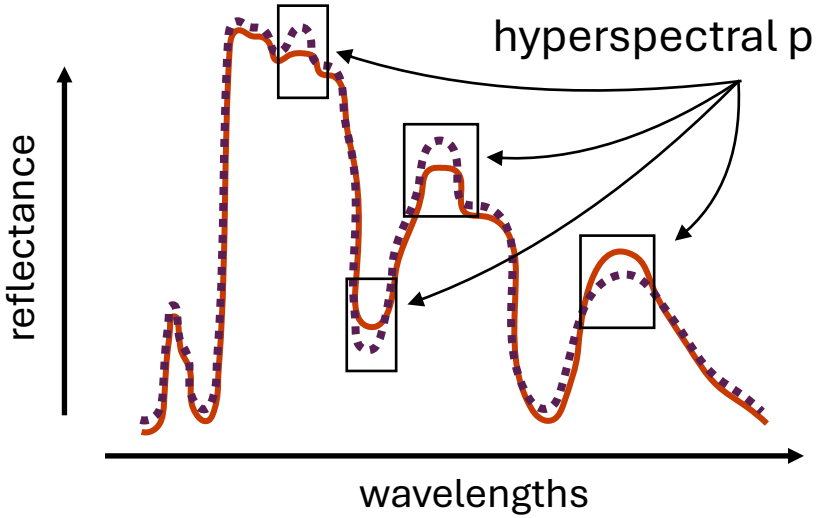
Regress chloride data on spectral profiles

Modelling strategies

Predict chloride content (PLSR, RF, SVM)

Predict classes (PLSDA)

hyperspectral profile changes

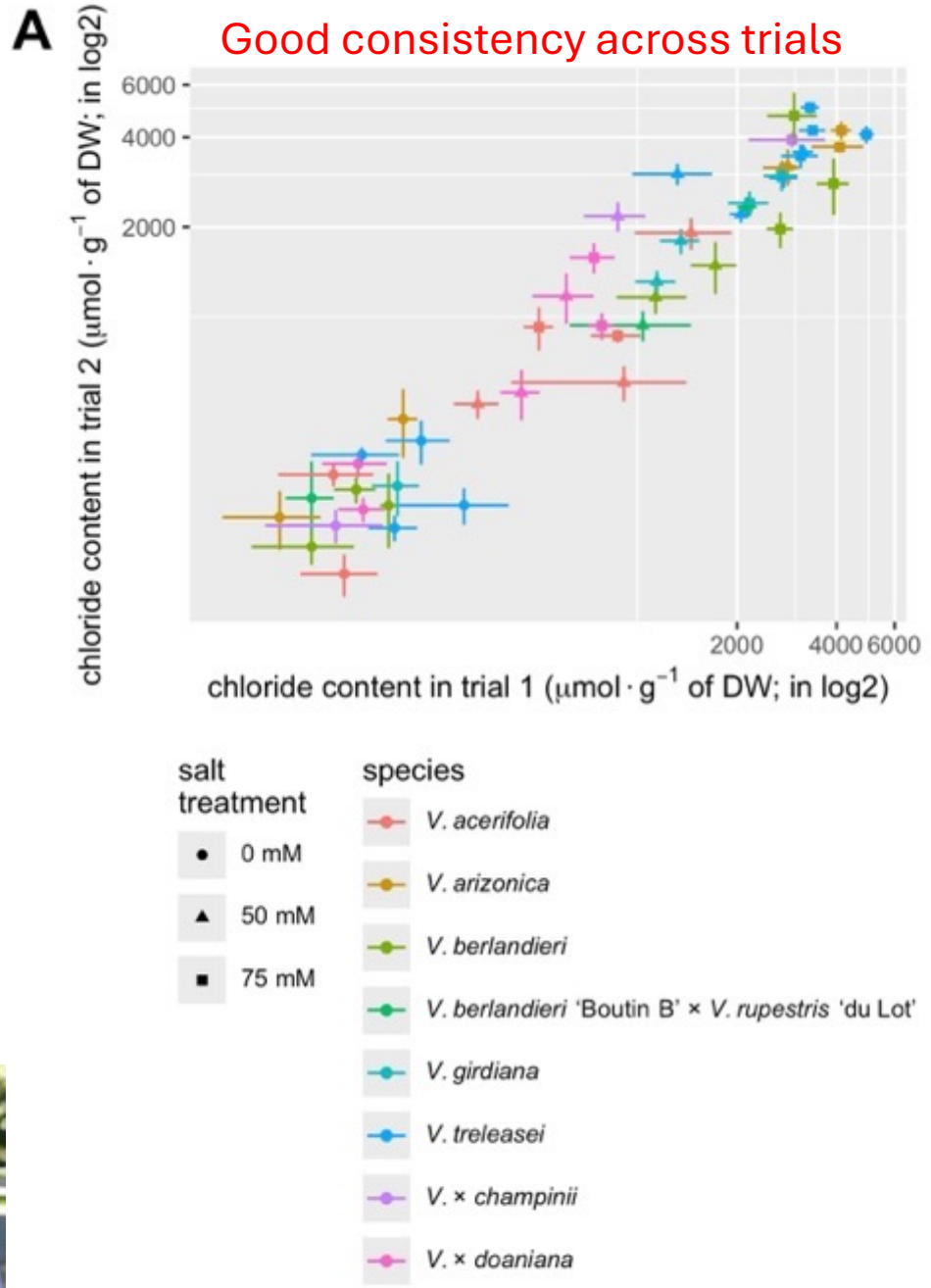


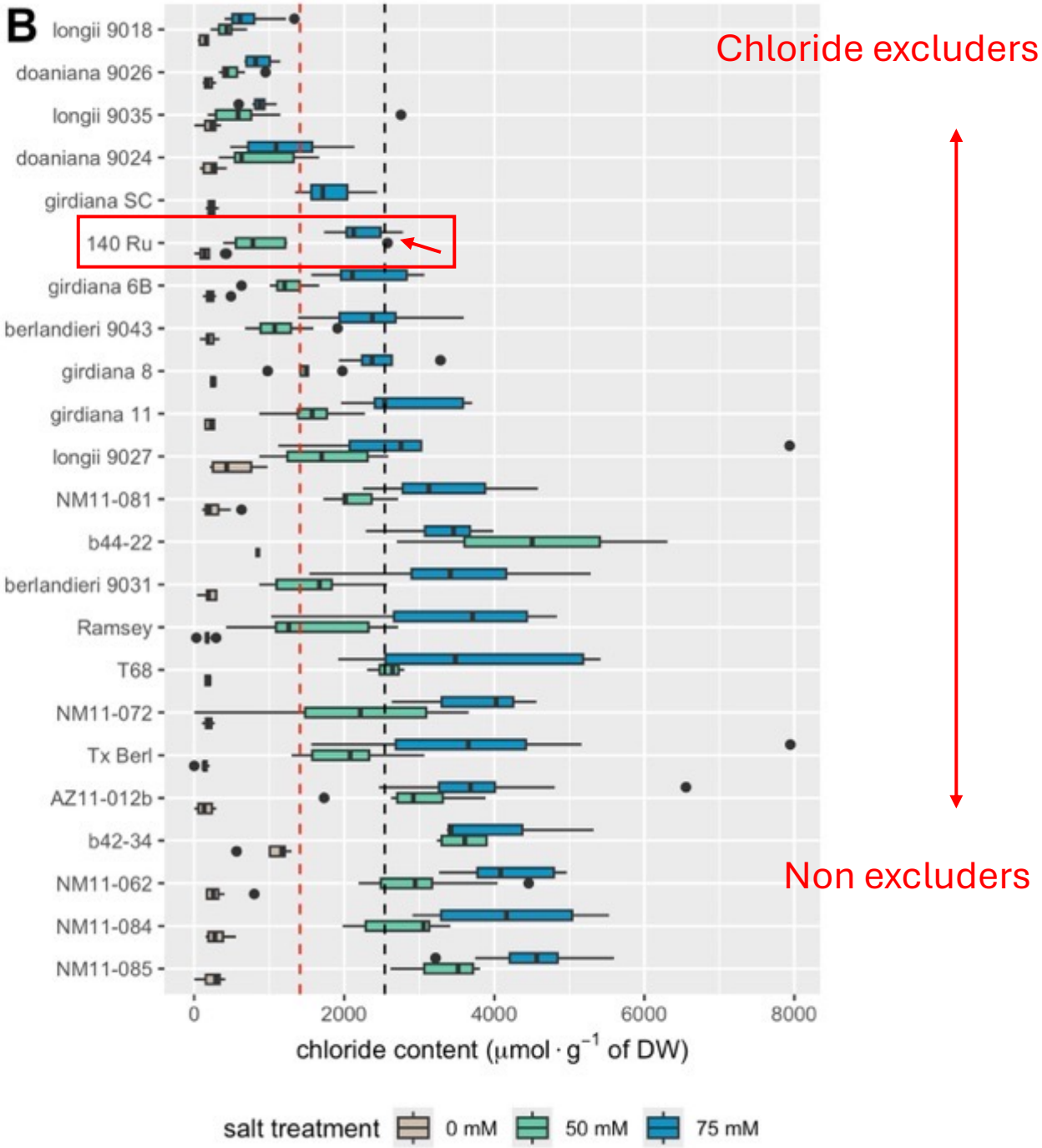
Tests with different spectrometers

HR-1024i
350-2500 nm
$$$$$

CI-710
360-1100 nm
$$

NIR-S-G1
900-1700 nm
$

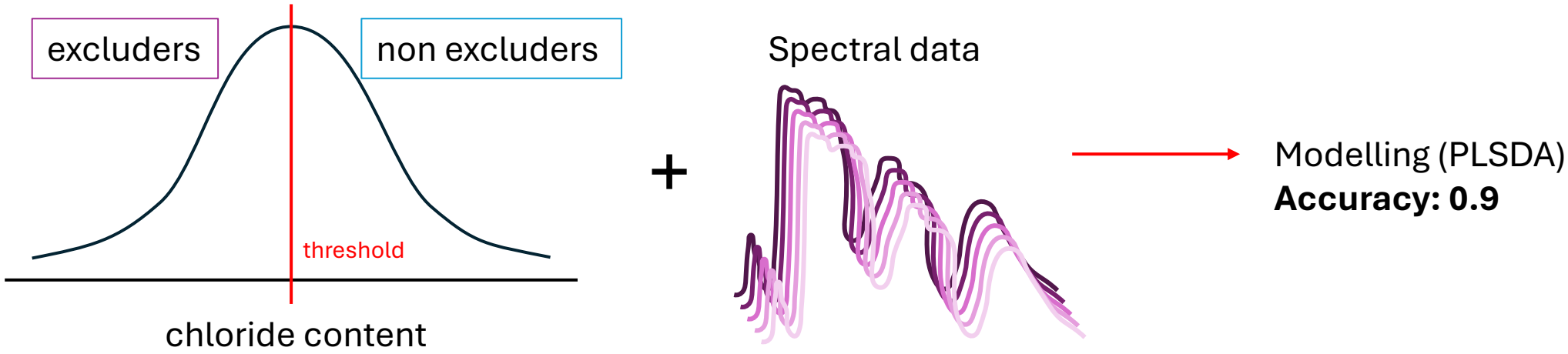




Sadikshya Sharma

Predicting chloride content is challenging, but the prediction of excluders is feasible

- Prediction accuracy for **chloride content** was <0.5, depending on the method (PLSR, RF, SVM, spectra transformations)
- However, **classes can be predicted with accuracy >0.9**
  - Excluders and non-excluders are determined based on a threshold
  - PLSDA models are trained with these classes



Model development for boron screening

- We do not have the equipment to measure
- $18/sample at the analytical lab, and it's destructive

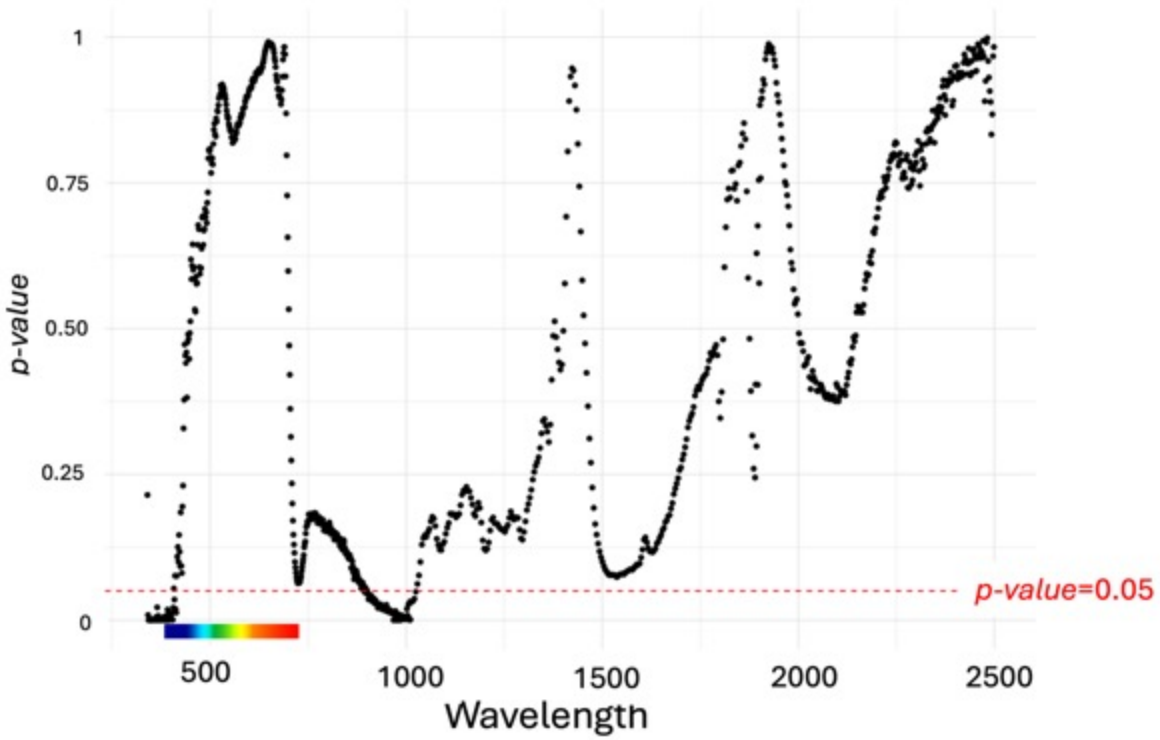
- Current experiment:
  - 20 *Vitis* species
  - 4 weeks of stress
  - 5 boron treatments
    - 0.5 ppm (control)
    - 1 ppm
    - 2 ppm
    - 4 ppm
    - 8 ppm

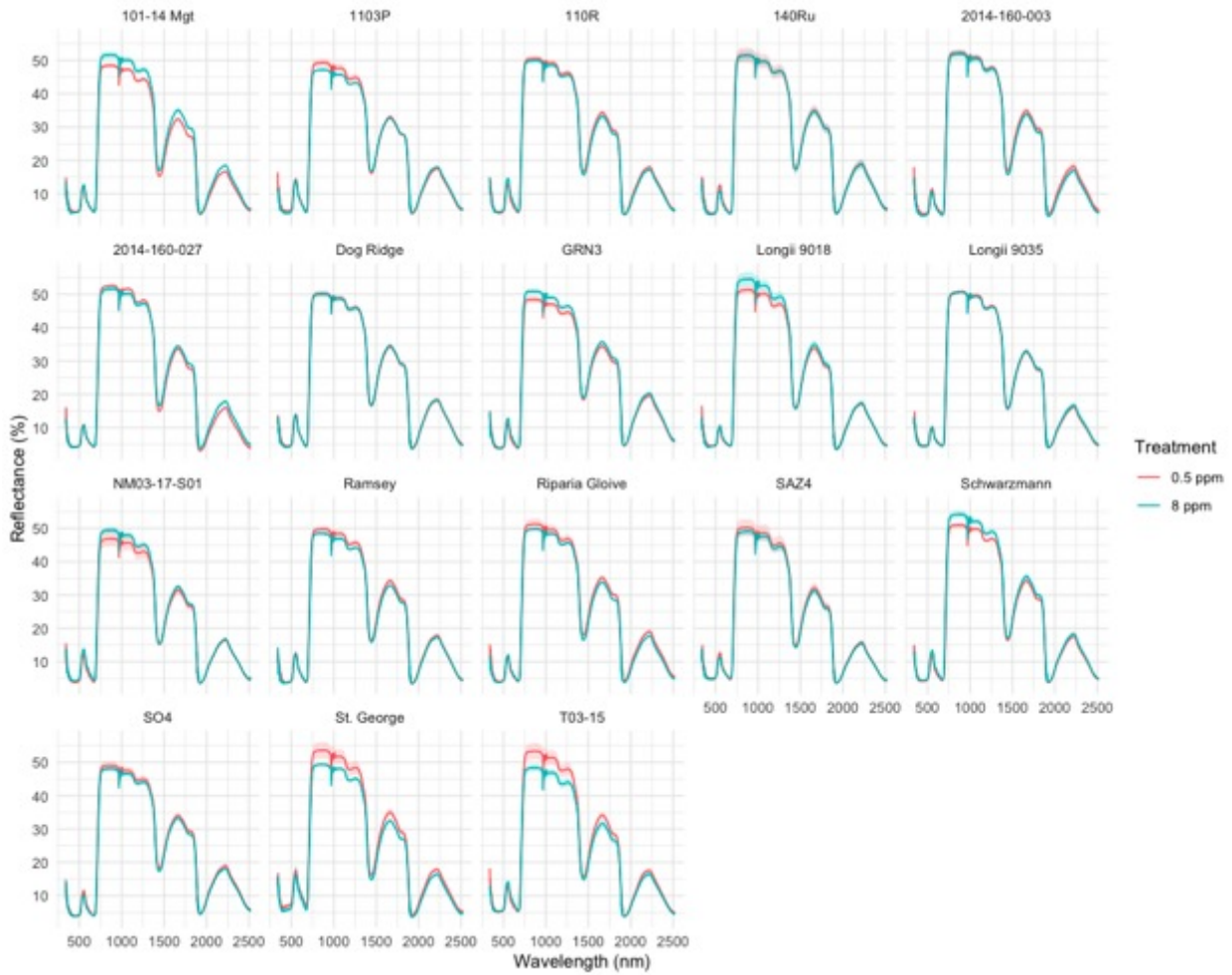
Yaniv Lupo


V. arizonica
1103P
control
8ppm
control
8ppm

Most of the differences at early stages appear in the NIR range

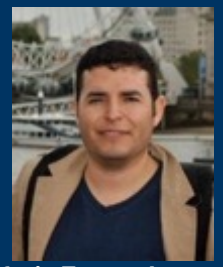
ANOVA (reflectance ~ boron treatment)





Our Team

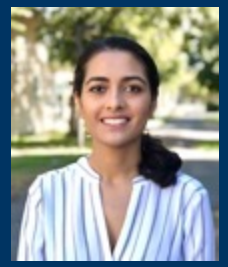
Jose Munoz
PhD, Hort & Agron



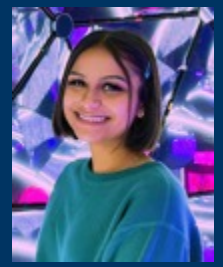
Efrain Torres-Lomas
ML specialist

Veronica Nunez
Field Manager

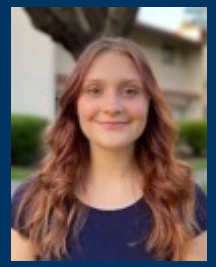
Yaniv Lupo
Postdoc



Sadikshya Sharma
PhD, Hort & Agron

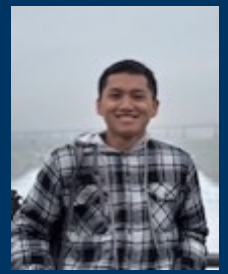


Sabrina Colacion
Undergrad



Mikayla Bailey
Undegrad

Paulina Gaspar
Lab Manager



Hollywood Banayad
PhD, Biophysics

Dan Ng
Crossing master

Cantu Lab
Chris Chen
Claire Heinitz
Guillermo Garcia Zamora

Previous breeders at the program

https://diazgarcia.github.io