How fungicide pressure, sexual reproduction and fitness shape QoI and SDHI resistance dynamics in grapevine powdery mildew populations in South Africa

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Table Grape Conference 2026



Grapevine Powdery Mildew

Erisyphe necator

- **Huge economic losses in South Africa**
  - Lower quality and quantity of grapes
  - Cost associated with fungicides
    - Viticulture has one of the highest use of fungicides
  - Financial loss exceeds 30% of production costs

Obligate biotrophic fungus

- Require green tissue to survive





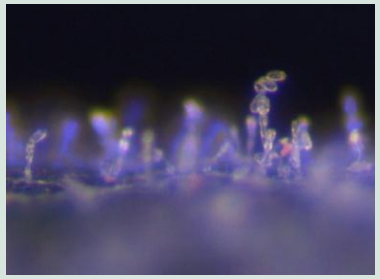

Stummer et al. (2000), Rantsiou et al. (2020), Pool et al. (1984), Gadoury et al. (2001), Calonnec et al. (2004), Fuller *et al.* (2014) & Sambucci et al. (2019)

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Life Cycle

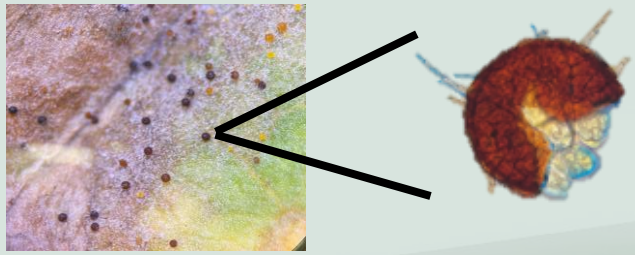
Sexual and Asexual

- **Asexual stage:** overwinter in buds and give rise to flagshoots - 0.2% incidence (Gadoury et al., 1988)



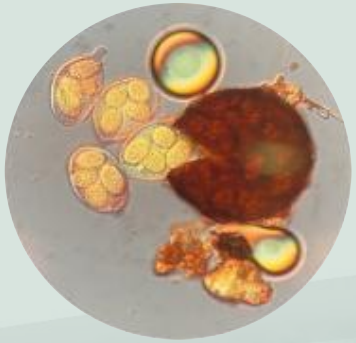


- **Sexual stage:** Ensure the survival of inoculum in winter
  - **Overwintering** structure (**chasmothecia)**
  - **Heterothallic** mating system
    - *MAT1-1* & *MAT1-2*



Concerns

- Allow organisms to **adapt** to changing **environments**
  - Associated with shifts in **fungicide sensitivity**
- **Significant increased** incidence and prevalence of chasmothecia
  - **1999** – Only immature Stellenbosch (Halleen & Holz, 2000)
  - **2025** – Mature widespread WC and NC (Janse van Rensburg, 2025





Billiard et al., 2012, Drenth et al., 2019, Otto, 2009, Bell, 1982, Nieuwenhuis and James, 2016, Ni et al., 2011, Gadoury et al., 2012, Cochrane, 1974, Hamilton et al., 2013, Sephton-Clark and Voelz, 2018, Huang and Hull, 2017, Redl et al., 2021a

Problem Statement

Increased disease incidence in Western Cape vineyards and reported control failure. Despite well-calculated spray programmes. Industry suspects a shift in sensitivity to important actives.

Aim

Evaluate the level of sensitivity of powdery mildew isolates to SDHI and QoI fungicides and to characterise mutations associated with reduced sensitivity.

Objectives

1. Determine the geographical and temporal distribution of QoI resistance
2. Investigate SDHI fungicide sensitivity

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Objective 1

Determine the geographical and temporal distribution of QoI resistance

Investigate SDHI fungicide sensitivity

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Geographical distribution of G143A mutation

32 Vineyards

- 20 Single colonies collected per site
  - “Scotch tape” **in the field**
  - Inspected leaves for **sexual structures**

Isolates

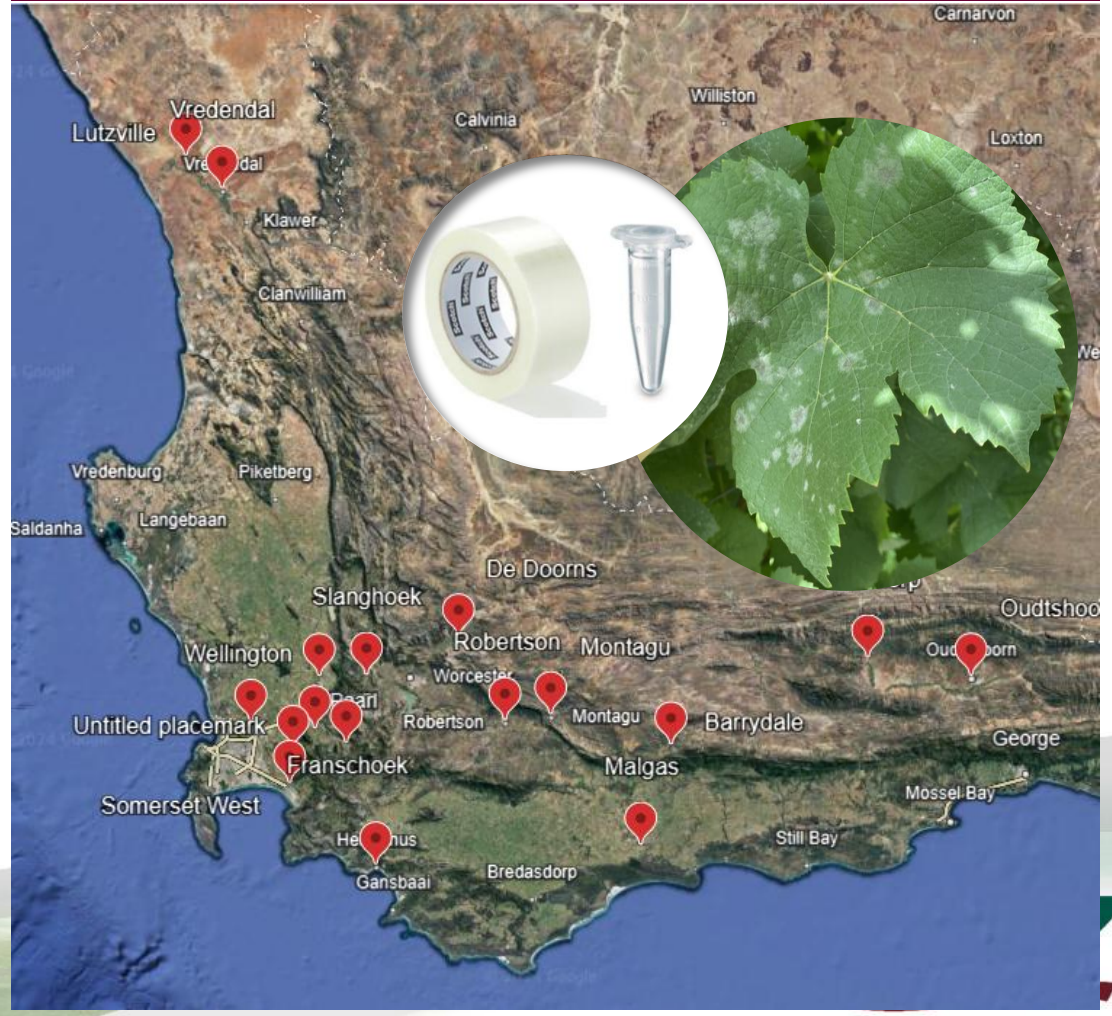
- DNA extractions
- 696 isolates
  - Species-specific PCR
  - *MAT 1-1* and *MAT 1-2* PCRs

qPCR assay for G143A

Determine mutant (MT) or wildtype (WT) allele (G143A):

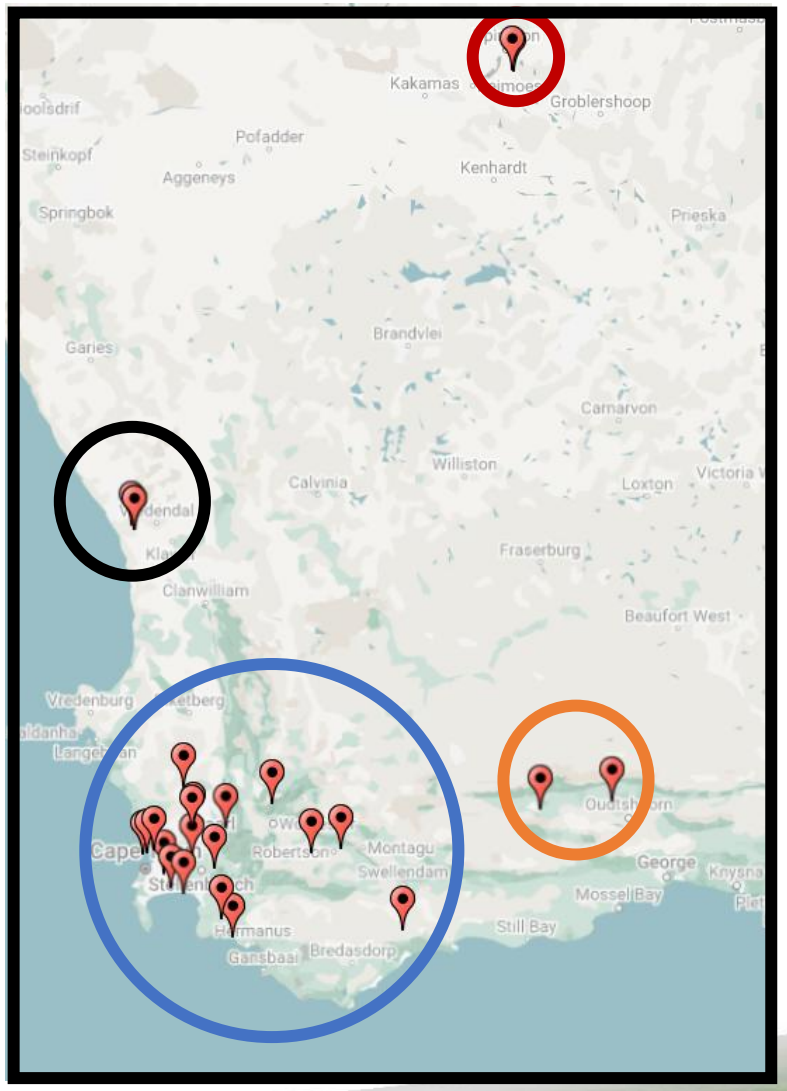
- Ratio of WT:MT per vineyard

Sampled single colonies (January – May 2024)

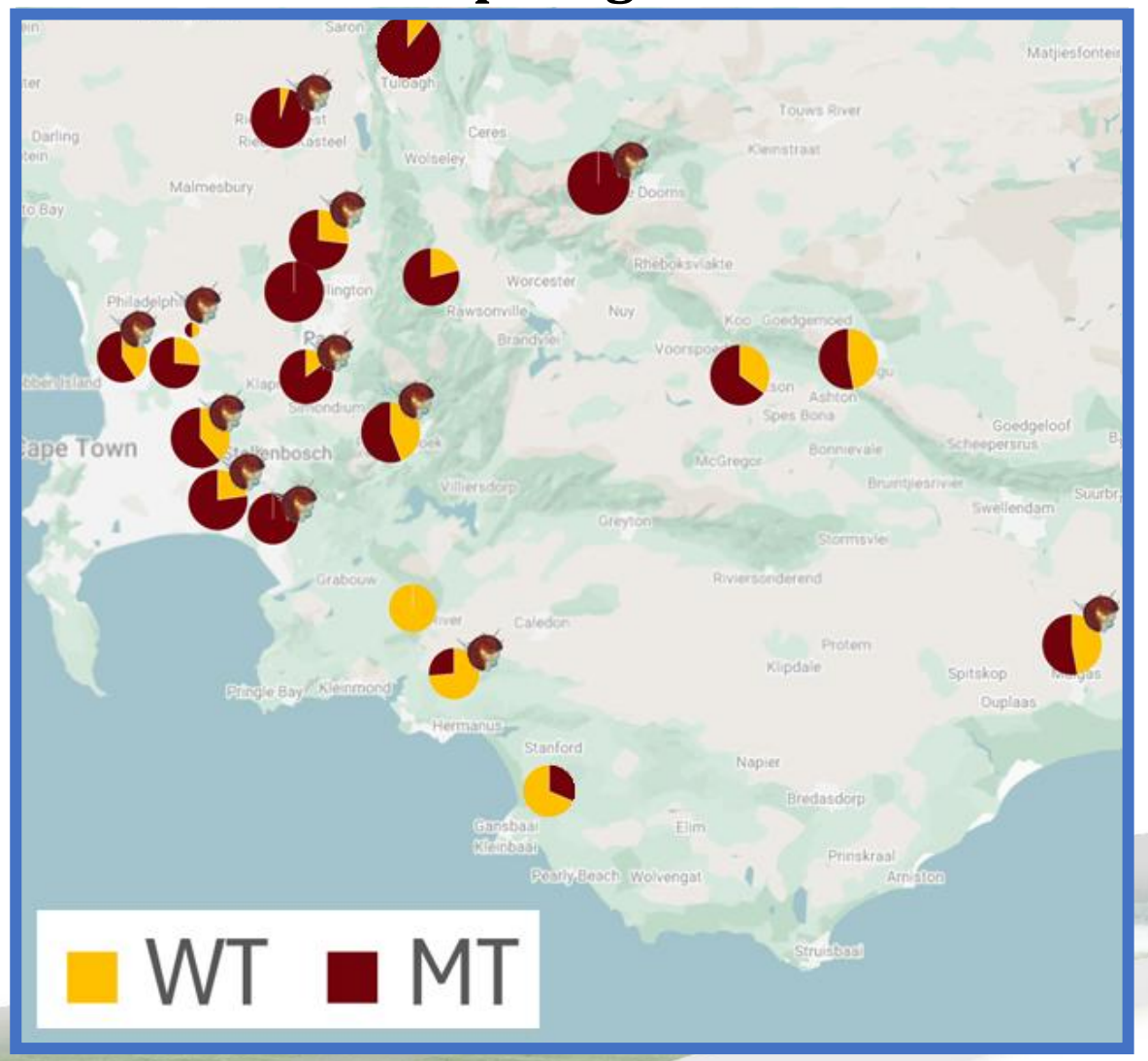


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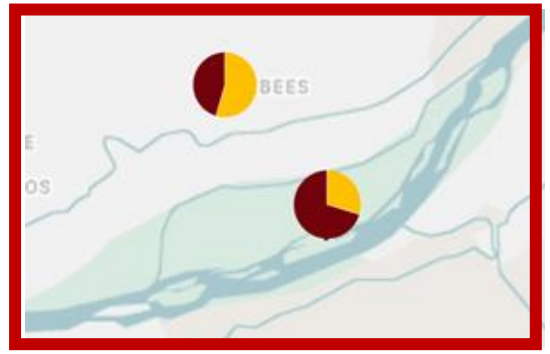
32 Vineyards



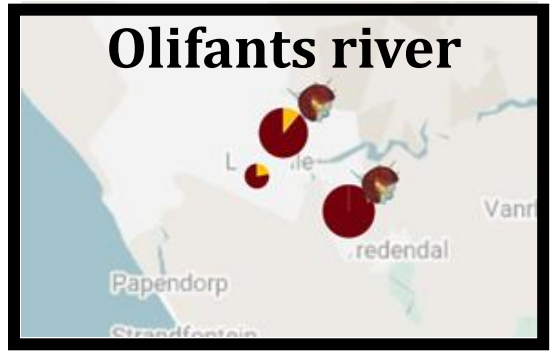
Cape region



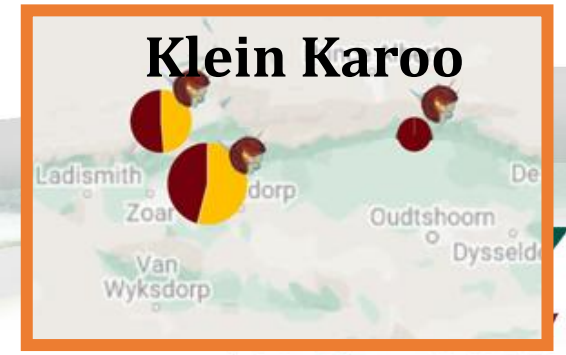
Orange river



Olifants river



Klein Karoo



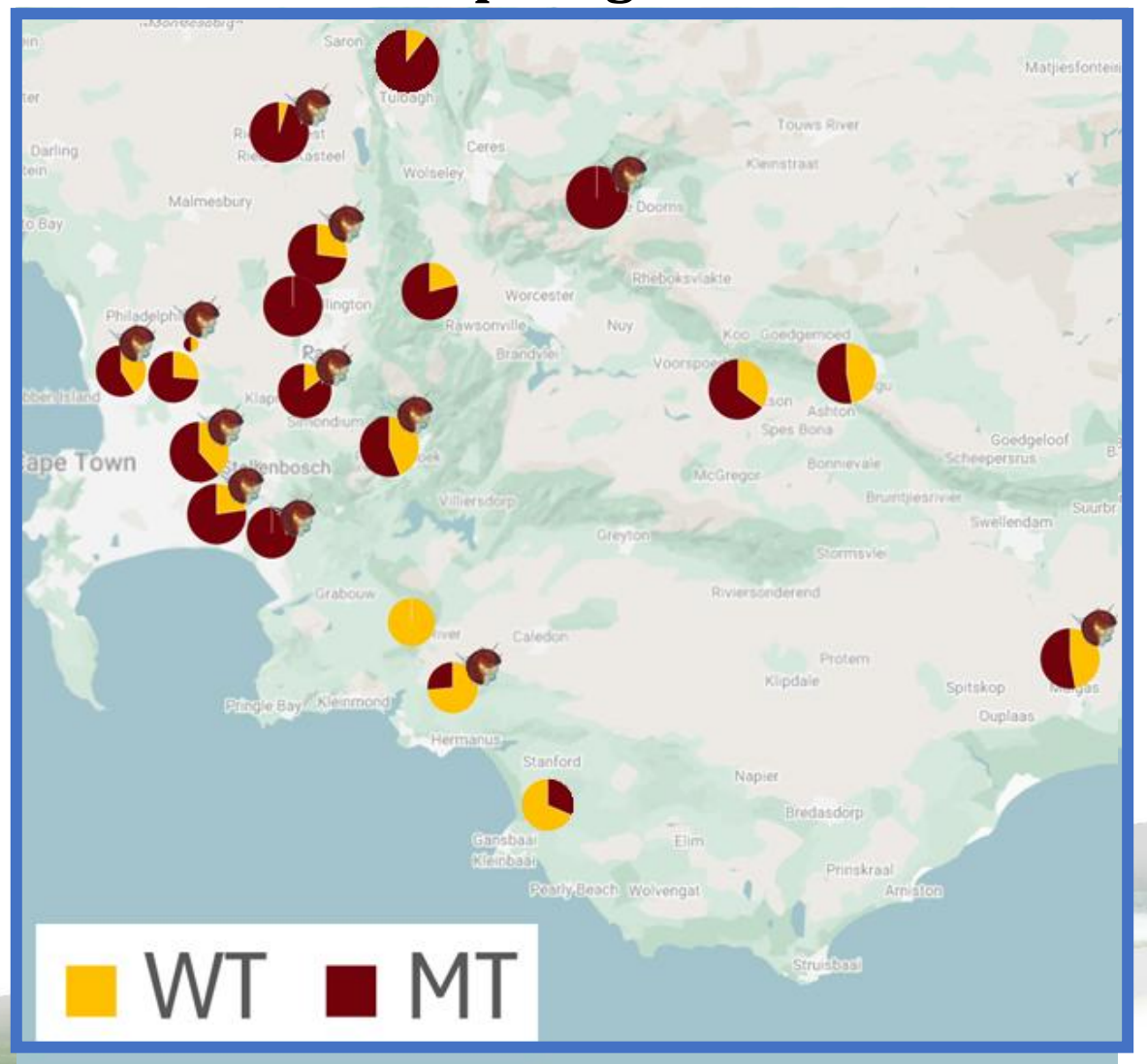
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MT:WT ratio over all populations

Mutant : Wildtype

- **Dominant MT**
  - 65.47% MT
  - 34.53% WT
- **Populations**
  - MT dominant – 19
  - Even – 10
  - WT dominant – 3

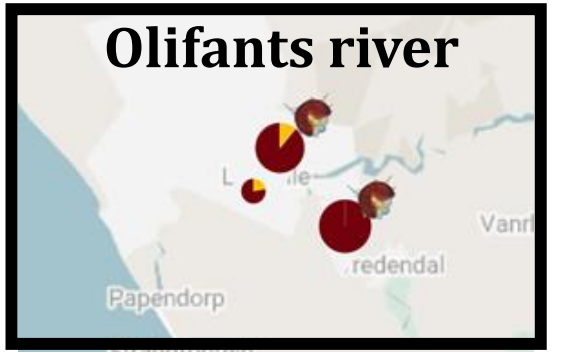
Cape region



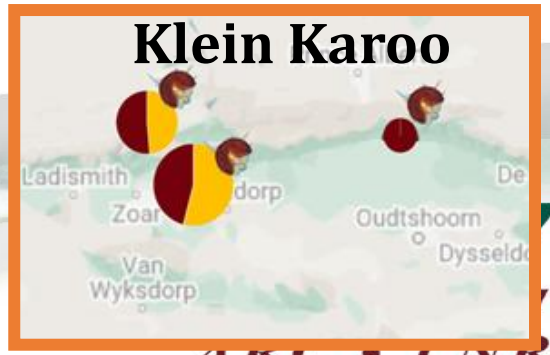
Orange river



Olifants river



Klein Karoo



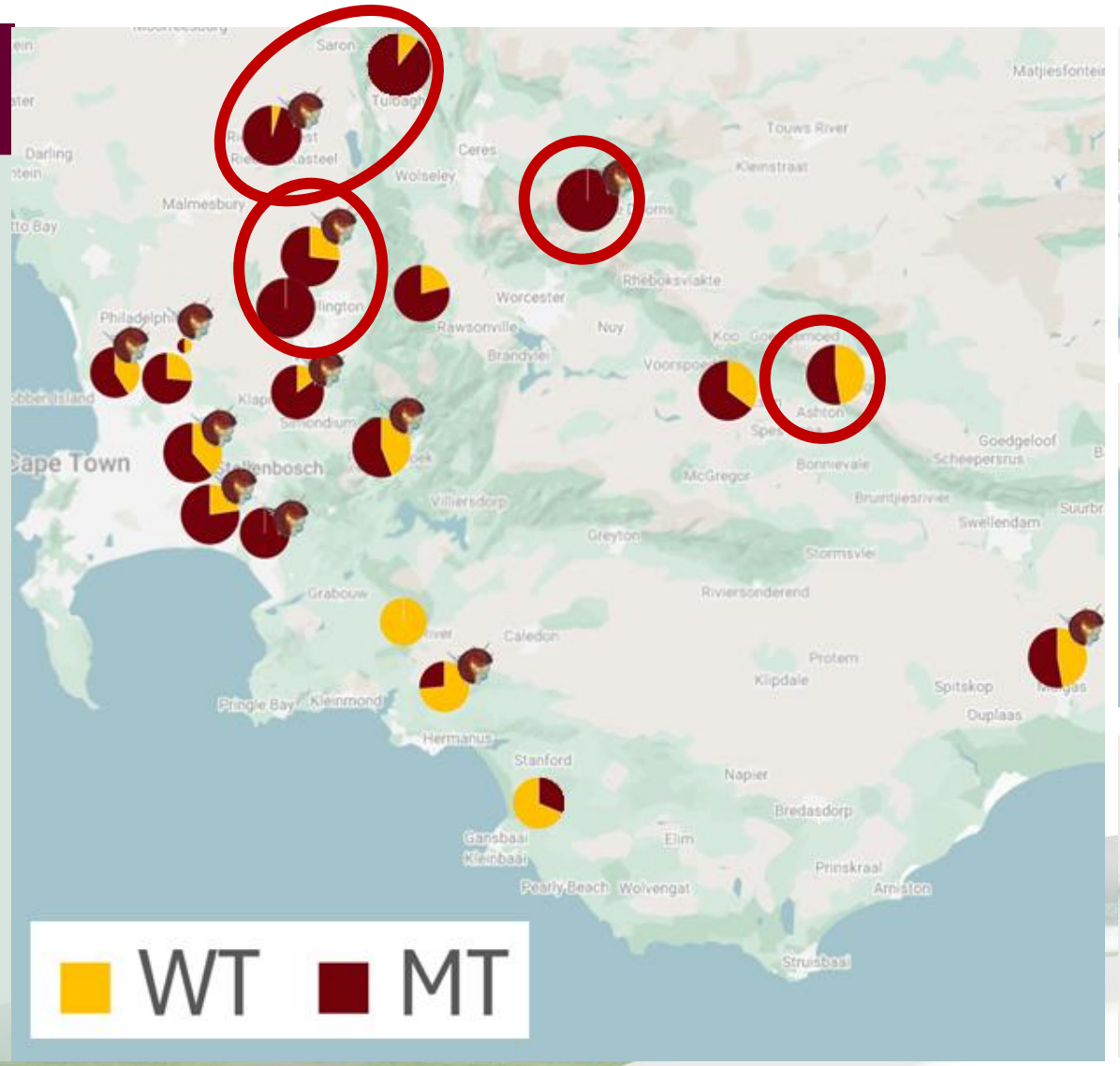
MT:WT ratio over all Table Grape populations

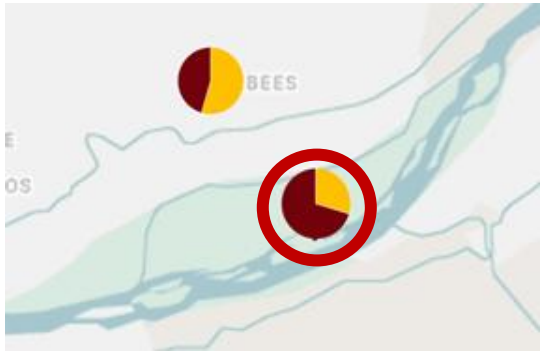
Mutant : Wildtype

- **Table vs Wine**

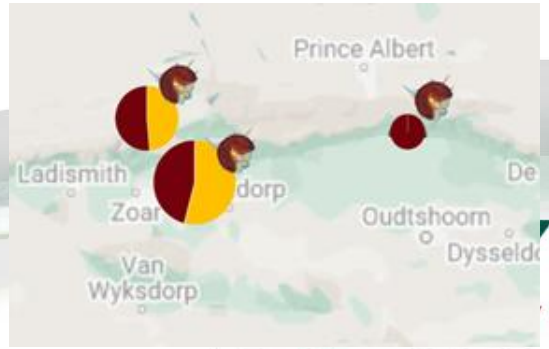
	WT	MT
Wine grape (22)	39%	61%
Table grape (10)	22%	78%

- **Table grape distributions**
  - MT dominant – 6
  - Even – 4
  - WT dominant – 0









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Temporal distribution of G143A

Two table grape vineyards

- Known history of PM

Sampled biweekly

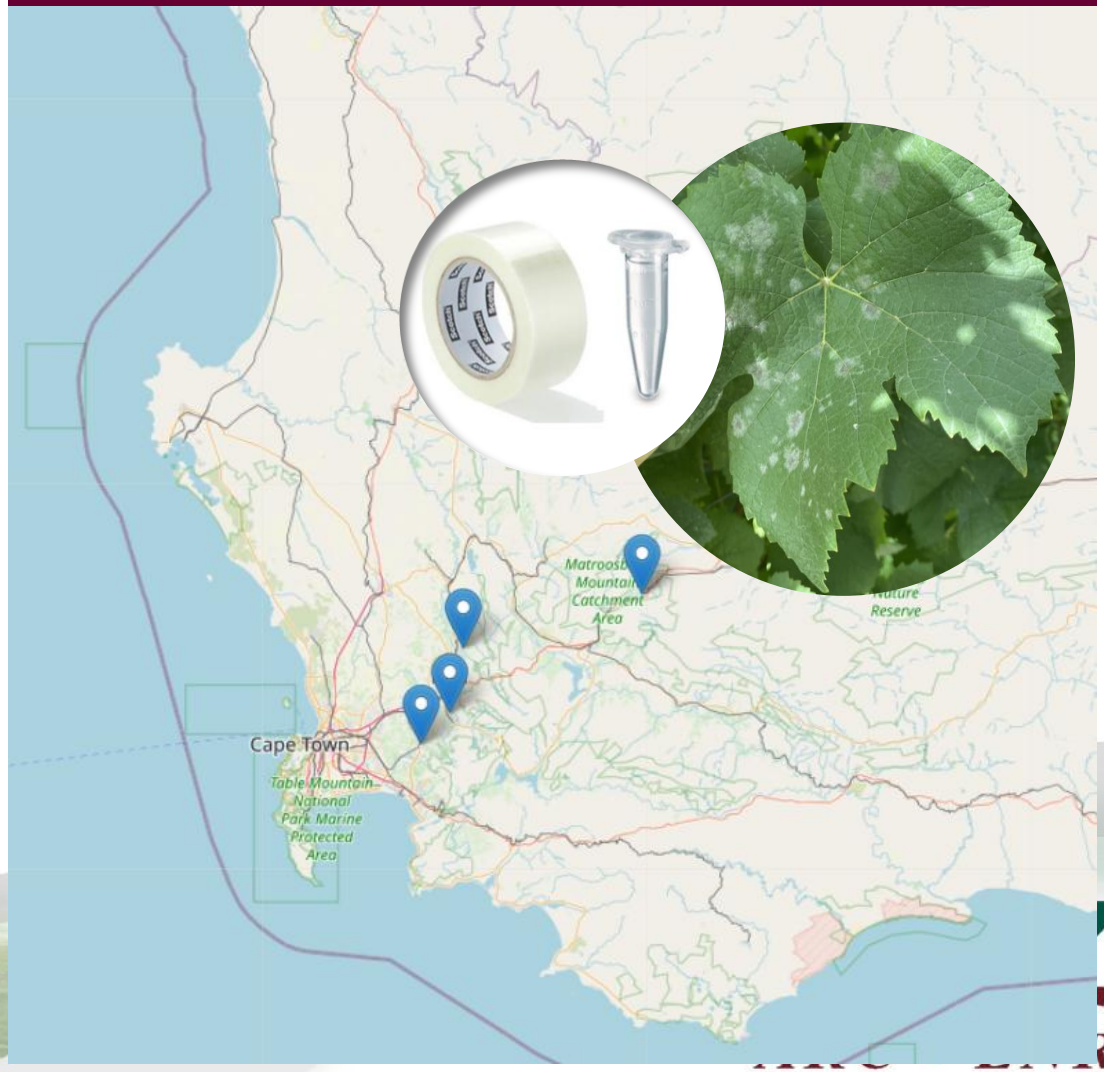
- Colonies collected using Scotch tape
- Chelex 100 DNA extractions (Miles et al. 2021)
- Species-specific PCRs (Brewer and Milgroom., 2011)

Leaves observed for chasmothecia

qPCR assay (Chi-square analysis)

- Taqman probe assay (Miles et al., 2021)

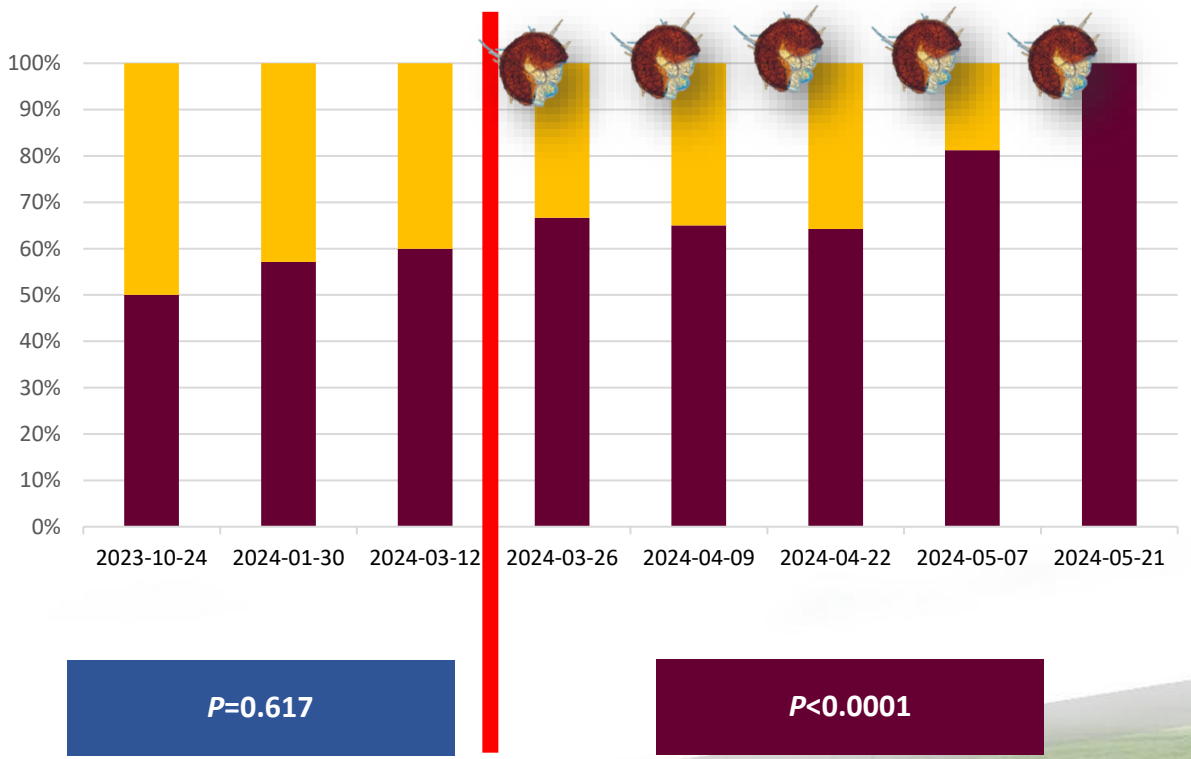
Sampled single colonies



Gur et al., 2025 (Israel)

- Resistance **starts** from a **small reservoir**
- **Rises** to a mid-season peak (**fungicide pressure**)
- **Declines** late season (**reduced sprays** and possible fitness costs)

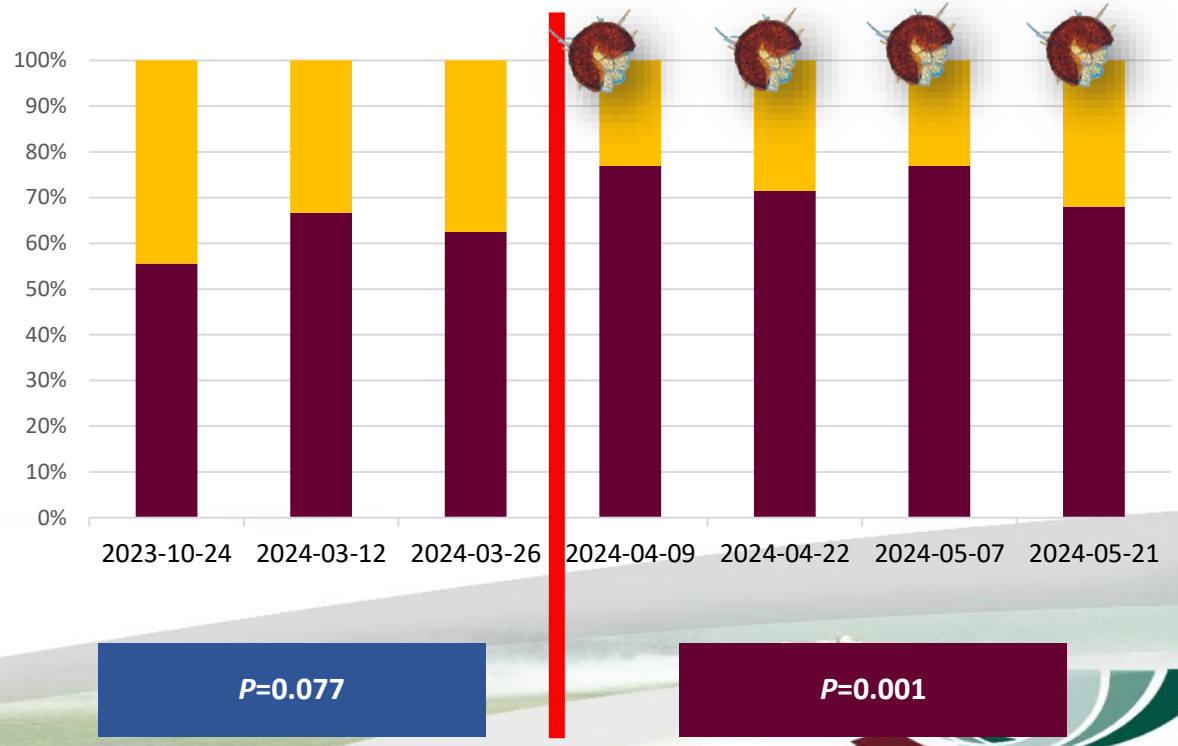
de Doorns



P=0.617

P<0.0001

Wellington



P=0.077

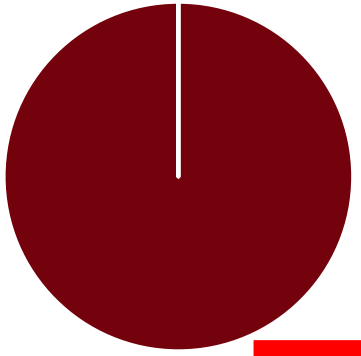
P=0.001

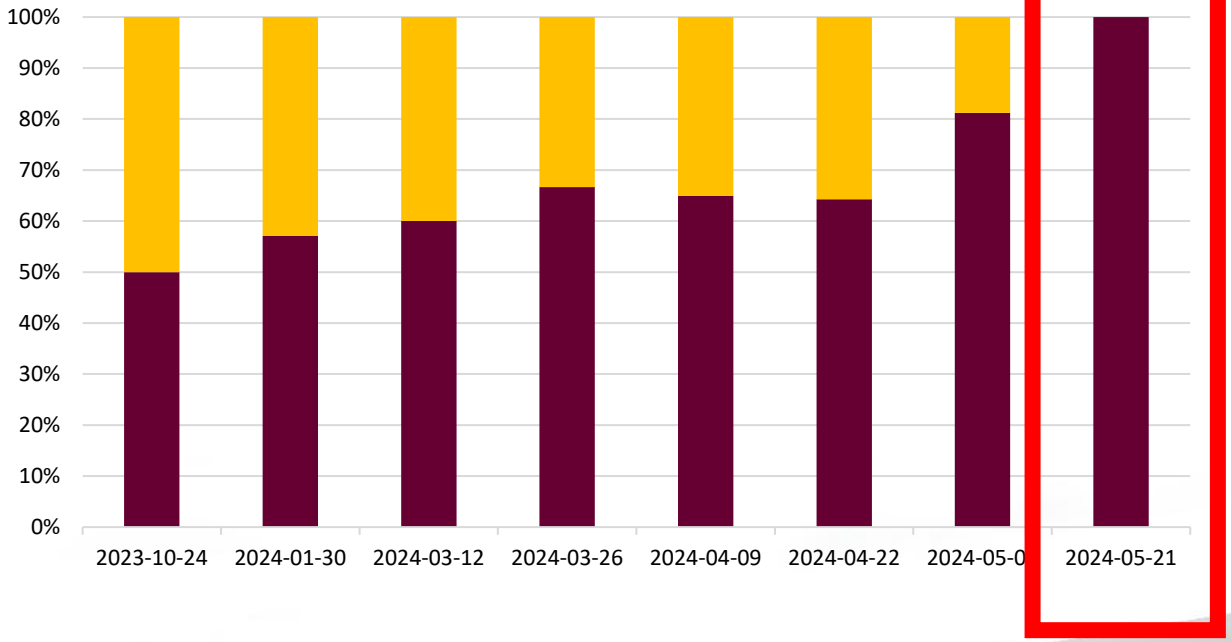
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Snapshot

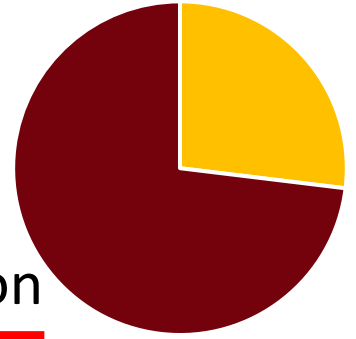
WT MT

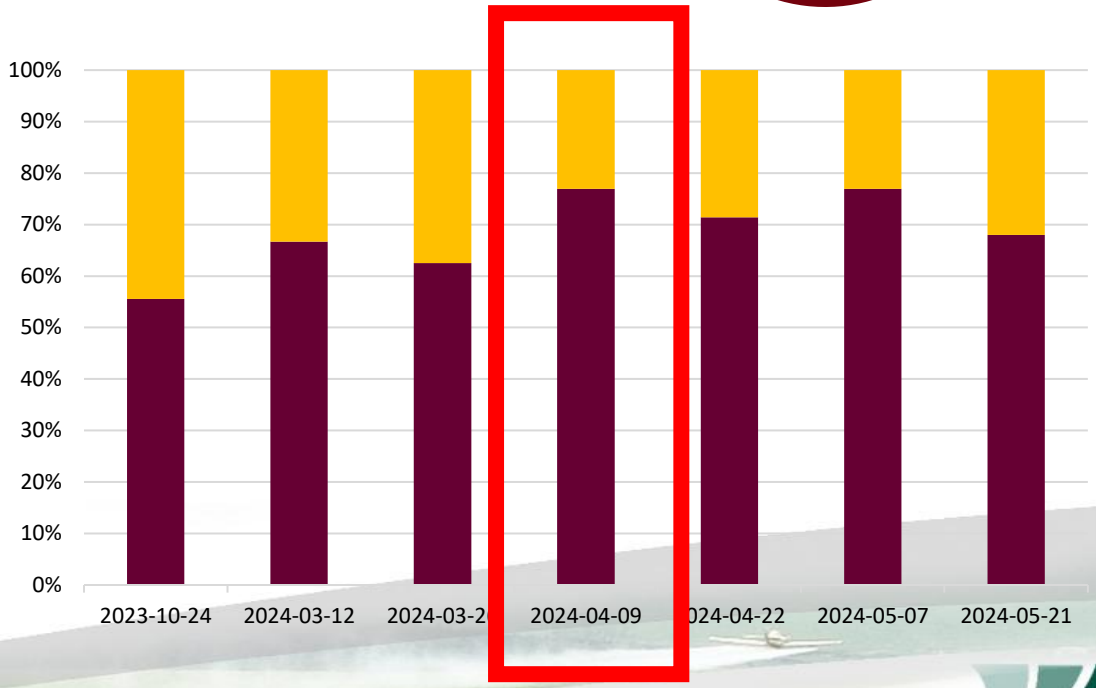
de Doorns





Wellington





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EC_{50} values associated with G143A mutation

Collect 20 symptomatic leaves

- 3 Table grape vineyards
- 4 Wine grape vineyards

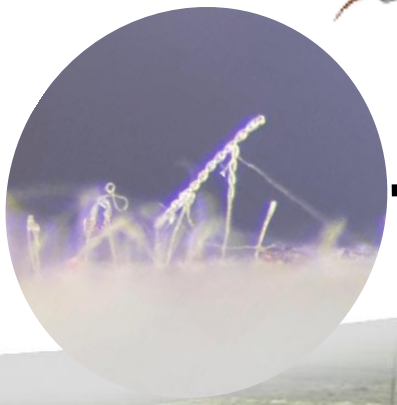
Fungicides (22 isolates)

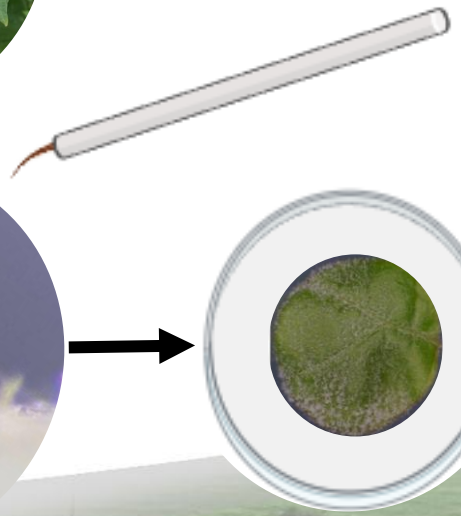
- Azoxystrobin and Pyraclostrobin
  - 0.1, 1, 10, 100 µg/mL
- Four replicates x isolate x concentration

qPCR

- Taqman probe assay

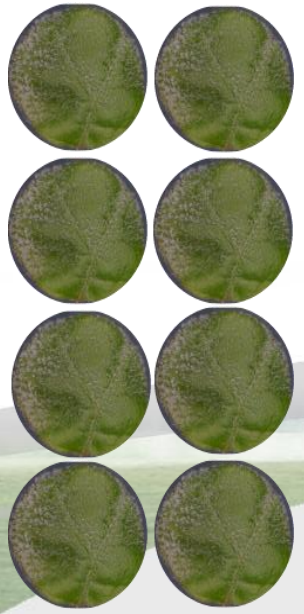




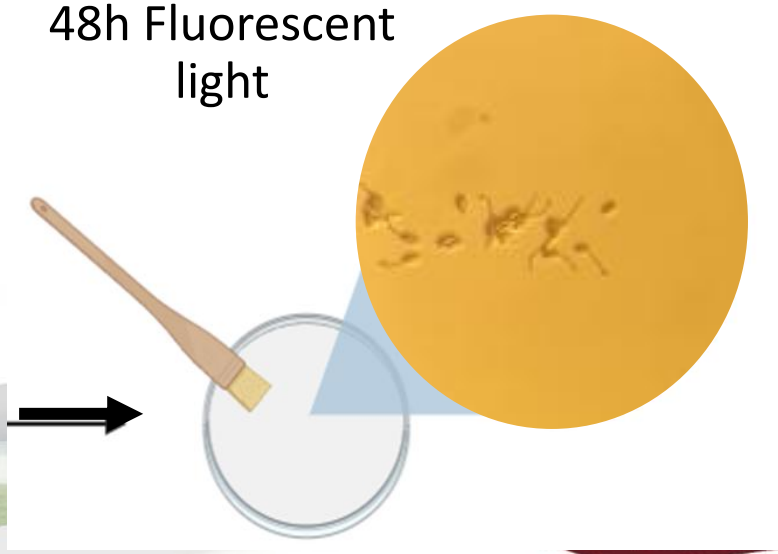


30 days 16hr
light/8hr dark cycle





48h Fluorescent
light



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QoI EC_{50} Values

All isolates: Wild-Type (n=22)

- **EC_{50} values =** 0.1-10µg/mL
- **qPCR** and **Sanger sequencing (WT)**
- **G143A mutation (> 100µg/mL)**

Strobilurin (QoI) Resistance in Populations of *Erysiphe necator* on Grapes in Michigan

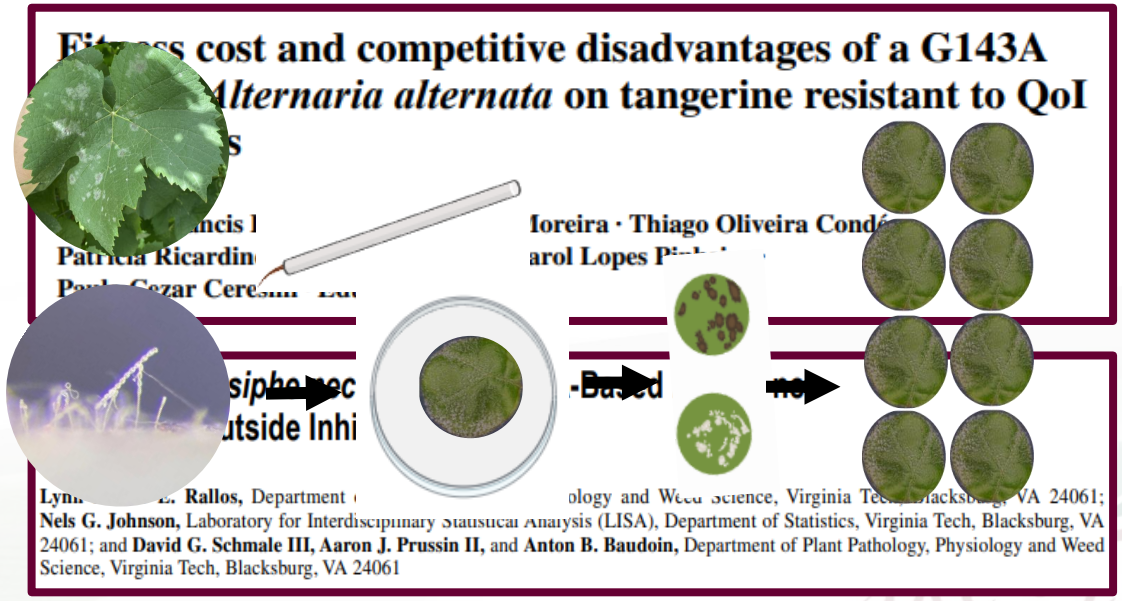
L. A. Miles, T. D. Miles, W. W. Kirk, and **A. M. C. Schilder,** Department of Plant Pathology, Michigan State University, 107 Center for Integrated Plant Systems, East Lansing, MI 48824

Occurrence and dynamics of resistance to a QoI and a DMI fungicide in *Erysiphe necator* the causal agent of grape powdery mildew in Israel

L. Gur [a,b,c,*], Y. Cohen [b], O. Frenkel [c], S. Ovadia [d], M. Reuveni [a,**]

Isolation pipeline for highest fitness

- ***Alternaria*** **-** Fitness penalty associated with G143A
- ***Erisyphe necator*** **(grapevine powdery mildew):**
  - 2014: No fitness penalty
  - 2025: Fitness penalty
    - **Less MT** isolates **early** in growing season
    - Under **DMI fungicide pressure** WT isolates outcompeted MT
    - **Resistant populations declined** after prolonged withdrawal of QoI fungicides (2yrs)



Objective 2

Determine the geographical and temporal distribution of QoI resistance

Investigate SDHI fungicide sensitivity

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Determine SDHI EC_{50} values



64 isolates

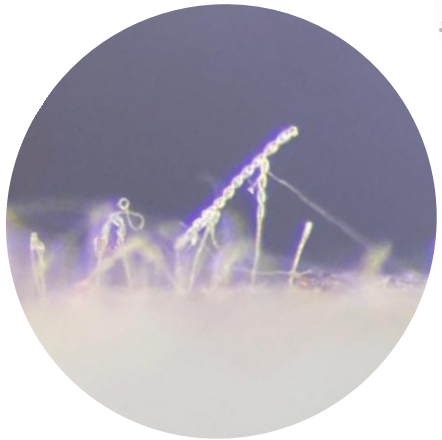
SDHI Fungicides

- Boscalid and Fluopyram
  - 0.1, 1, 10, 100 µg/mL



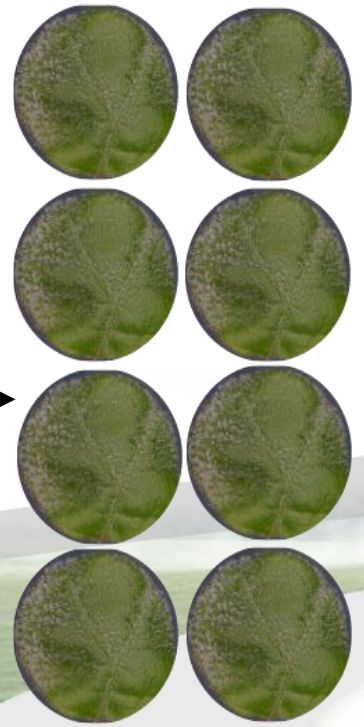
30 days 16hr light/8hr dark cycle

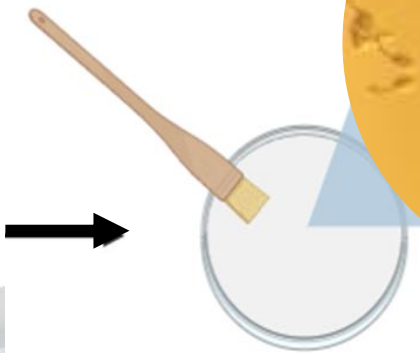
48h fluorescent light

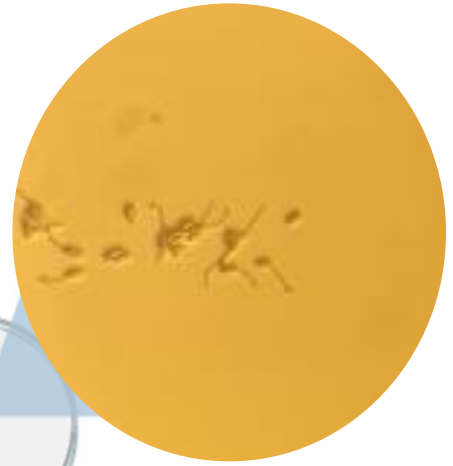












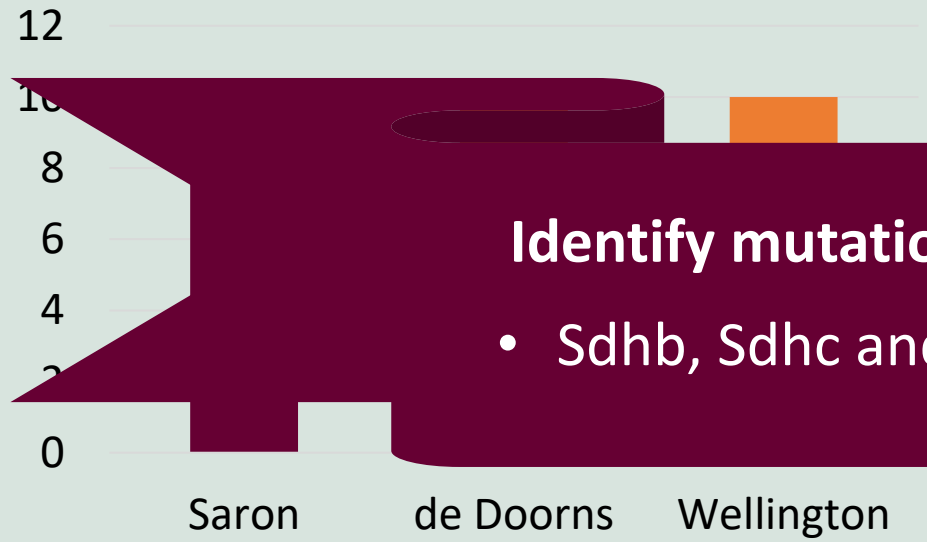
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Sensitive (1-10µg/mL)

SDHI EC_{50} values

Resistant (>100µg/mL)

Fluopyram (n = 64)



75% Sensitive isolates
25% Resistant isolates

Boscalid (n = 41)



72% Sensitive isolates
28% Resistant isolates

Identify mutations and correlate to EC_{50} values

- Sdhb, Sdhc and Sdhd

69% with similar sensitivity to both actives & 31% had differing sensitivities

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SDHI mutations

Four global studies on GPM

- Only determined EC_{50} values for **5-20 isolates**
  - SDHB - H242R, H242Y, I244V
  - SDHC - G169D
  - **EC_{50} values did not always correlate to SNP's**

Differing levels of sensitivity but no correlating mutations

- **Non-target-site mechanisms** (e.g. efflux transporters, regulatory or epigenetic changes) can reduce SDHI sensitivity and **are not detectable by sequencing** (Sang & Lee, 2020; Yin et al., 2023)

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Take home message

QoI MT are widespread through SA (78% in table grape vineyards)

- **First report of QoI mutation in South Africa**
  - **New Zealand: 100%** (Beresford et al., 2016) & **Germany: 90%** (pers comm, 2025)
- Observed **fitness penalty** for the **G143A mutation** in **SA populations**
  - **Reducing QoI selection pressure** could help maintain sensitive populations

Snapshot

- **Monitoring once** does **not** give the **accurate** representation of what populations are like
  - Need to monitor **over time** to understand distribution dynamics

Populations are sensitive to SDHI fungicides

- **Lower number of resistant isolates** (25-28%) and cross-resistance is unlikely
  - Protect SDHI's - **rotate** different SDHI actives and other fungicide actives
- **No mutations** characterised to be associated with resistant isolates
  - Reduced sensitivity could be due to **non-target-site mutations** (further study)

Acknowledgements

SOUTH AFRICA WINE
discover diversity in a glass

NRF

SATI
South African Table Grape Industry

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Stellenbosch
UNIVERSITY
IYUNIVESITHI
UNIVERSITEIT

Consultants and producers for samples

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