PHENOTYPING OF HEAT RESPONSE TRAITS IN A GRAPEVINE SEGREGATING POPULATION (*Rhine Riesling* x *Cabernet Sauvignon*)

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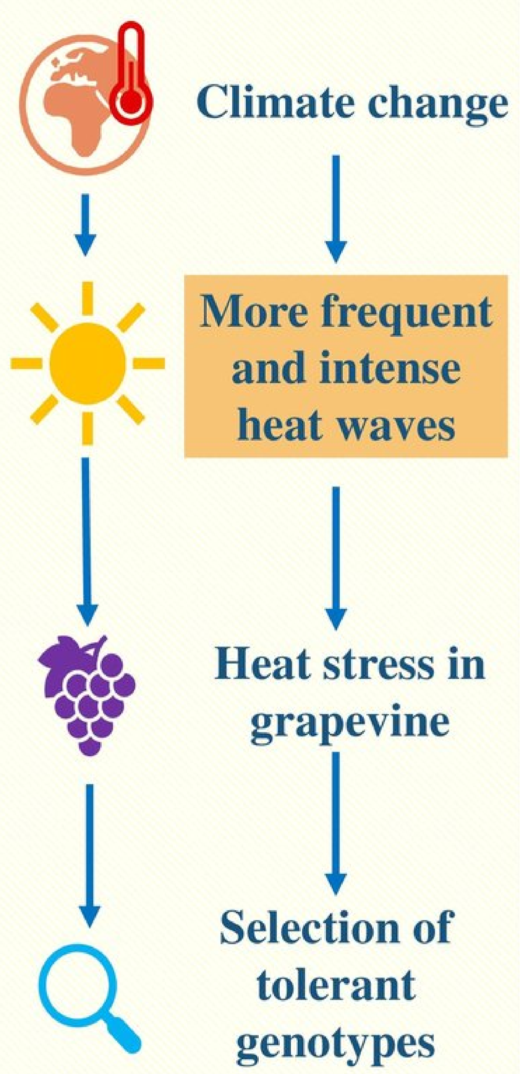
1. BACKGROUND & OBJECTIVES

Climate change is increasing the frequency and intensity of heat waves, posing a major challenge to sustainable grapevine cultivation (IPCC, 2023). **Identifying heat-tolerant genotypes** is therefore a key objective for future viticulture and breeding programs (Venios et al., 2020).

A **segregating population** (*Rhine Riesling* × *Cabernet Sauvignon*) was evaluated in an alpine vineyard during **natural heat events**, monitoring stomatal conductance (g_s), chlorophyll fluorescence, NPQ, and leaf temperature alongside environmental variables (Pettenuzzo et al., 2022).

This study integrates **proximal physiological measurements** with **UAV-derived thermal imaging** to identify contrasting genotypes and develop scalable phenotyping approaches. The resulting phenotypic data will support **QTL mapping** (Vervalle et al., 2022; Pettenuzzo et al., 2025) and contribute to **climate-resilient grapevine cultivars**.



2. EXPERIMENTAL DESIGN

POPULATION

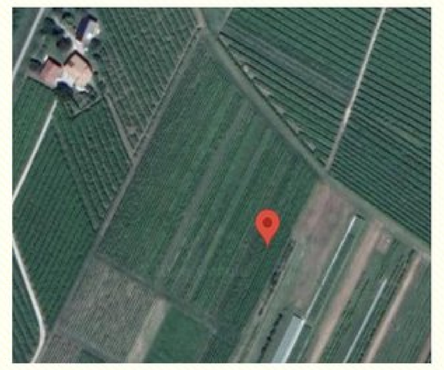
Rhine Riesling

X

Cabernet Sauvignon

Segregating population (166 genotypes)

EXPERIMENTAL FIELD



Edmund Mach Foundation in «Giaroni» San Michele a/A, Trentino-Alto Adige, Italy, 46°18′N, 11°13′E

MEASURED TRAITS

KEY PHYSIOLOGICAL TRAITS	INSTRUMENT
Stomatal conductance (g_s)	LI-COR LI-600 porometer
Chlorophyll fluorescence	LI-COR LI-600 porometer
NPQ	FluorCam
Leaf temperature (T_{leaf})	LI-COR LI-600 porometer
Leaf temperature (T_{leaf})	Thermal imaging (M3T + IR RGB 20MP)
PAR	LI-COR LI-600 porometer
VPD_{leaf}	LI-COR LI-600 porometer

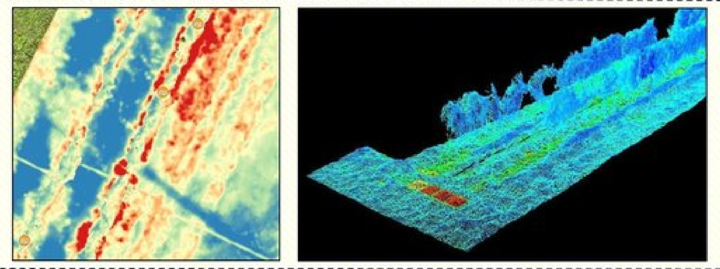
3. PHENOTYPING WORKFLOW

Field measurement on both sides of the row and at different times of the day

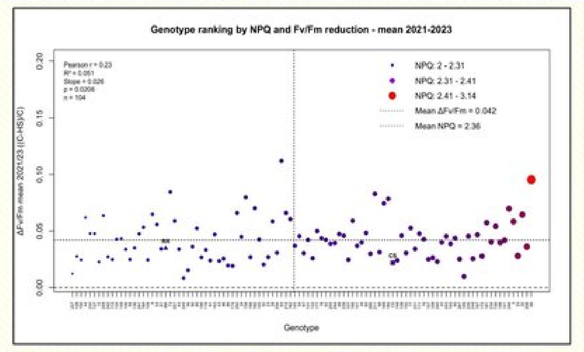
Physiological traits and **Environmental data** (F_V/F_M, VPD_{leaf}, PAR, etc)

UAV flights (thermal imaging)

Canopy temperatures maps



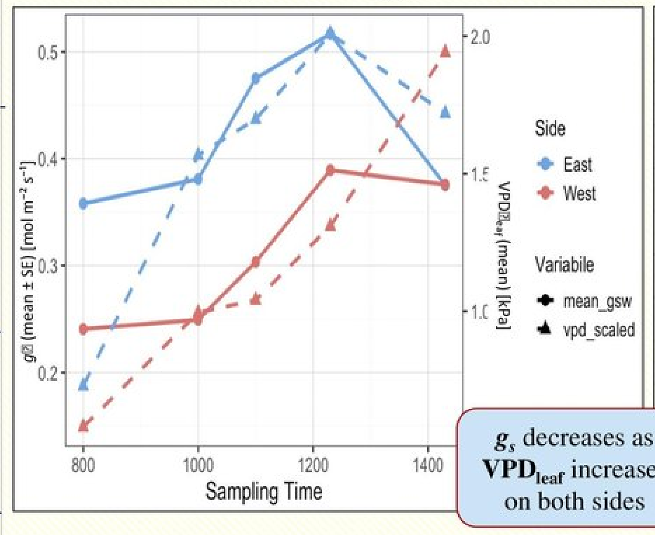
Genotypic performance estimation



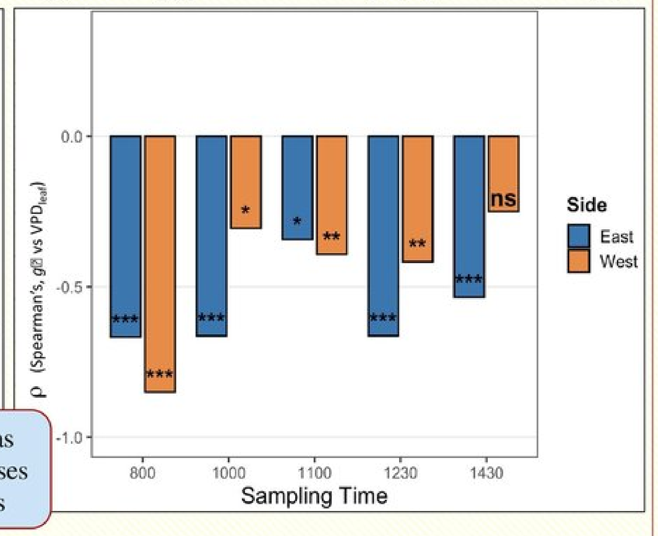
Selection of contrasting genotypes for further experiments

4. PRELIMINARY RESULTS

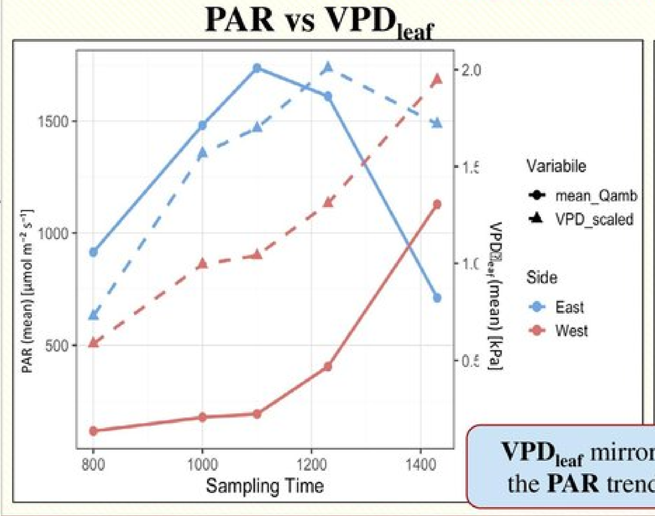
A. Environmental drivers



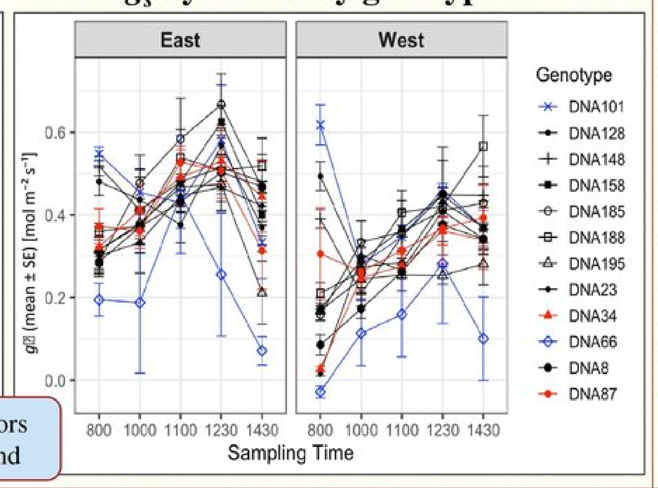
g_s decreases as VPD_{leaf} increases on both sides



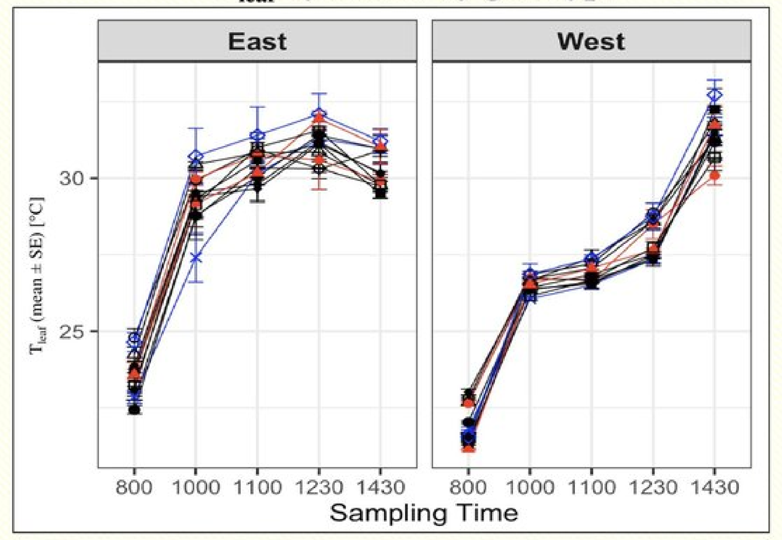
B. Radiation effects

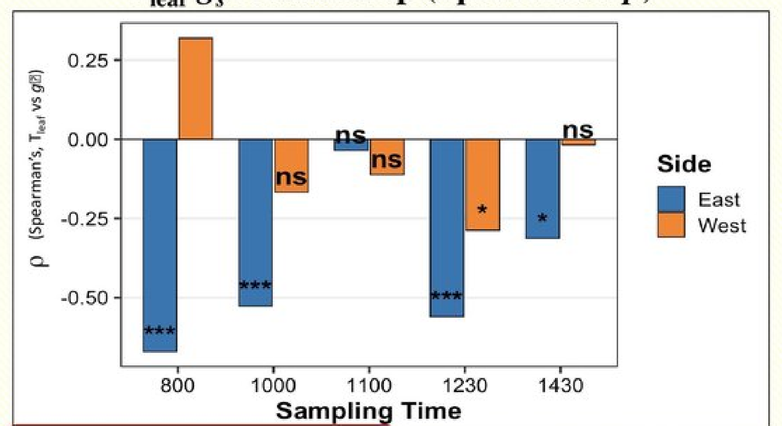


VPD_{leaf} mirrors the PAR trend



C. Leaf temperature response



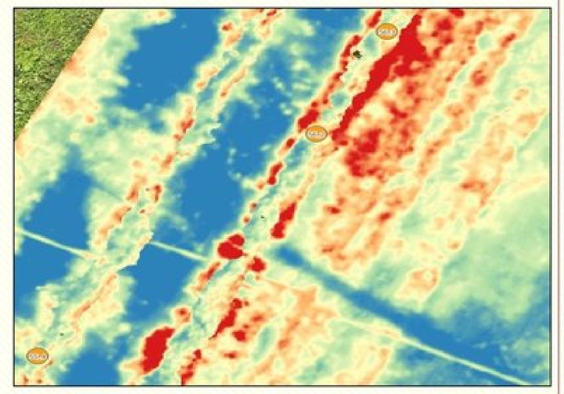


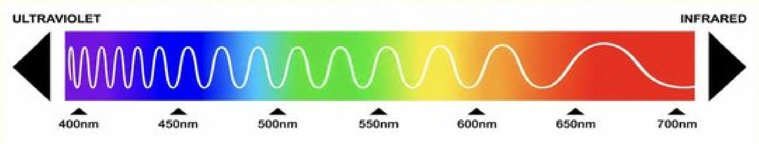
Stability differential in stomatal response: East > West

D. Thermal imaging (UAV)

RGB orthomosaic

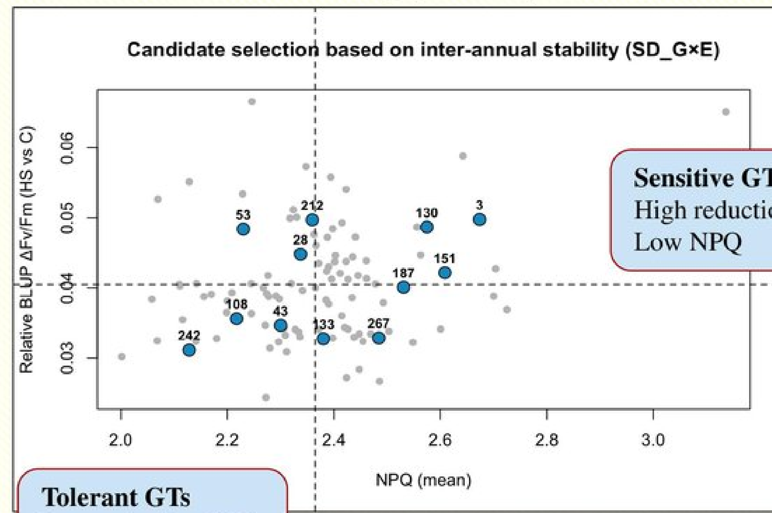
Canopy temperature (°C)





E. Genotypic performance (BLUPs)

NPQ (BLUPs)



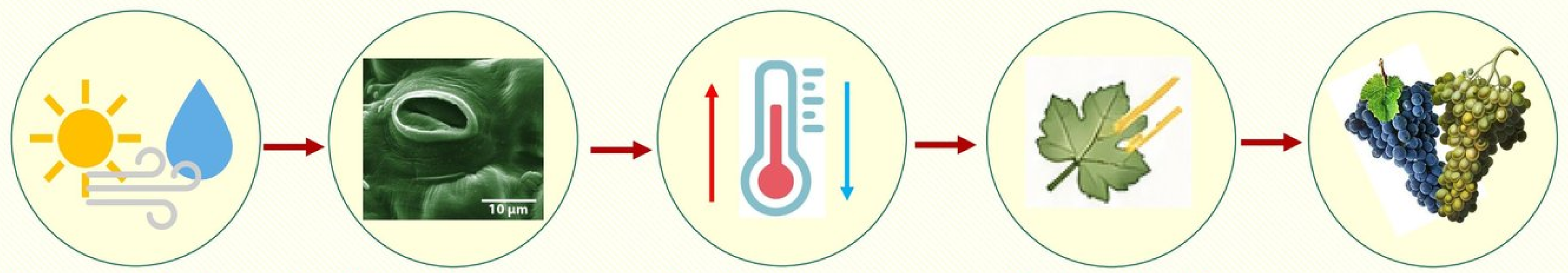
5. CONCLUSIONS

MAIN FINDINGS

- ✓ g_s is strongly associated with **PAR** and **VPD_{leaf}**.
- ✓ **Leaf temperature** reflects both stomatal regulation and radiation load.
- ✓ **Thermal imaging** successfully captured canopy temperature variation associated with physiological heat responses, supporting its use as a scalable phenotyping tool.
- ✓ **NPQ** and F_v/F_m responses, analyzed using **BLUPs**, identify genotypes with contrasting heat stress stable performance across years.

CONCEPTUAL MODEL: FROM ATMOSPHERIC DEMAND TO HEAT STRESS

Increasing radiation and atmospheric demand drive a physiological cascade toward heat stress



Atmospheric demand (PAR + VPD_{leaf}) → Stomatal response (g_s) → Leaf temperature (T_{leaf}) → Photoprotection (NPQ) → Heat tolerance

Increasing VPD_{leaf} / decreasing g_s/ rising leaf temperature →

NEXT STEPS

1. **Controlled heat stress experiment** to validate contrasting genotypes.
2. Integration with **QTL analysis** to unravel genetic bases of heat tolerance.
3. Development of **scalable phenotyping strategies** for vineyard management and grapevine breeding.
4. **Support the development** of climate resilient grapevine cultivars.

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